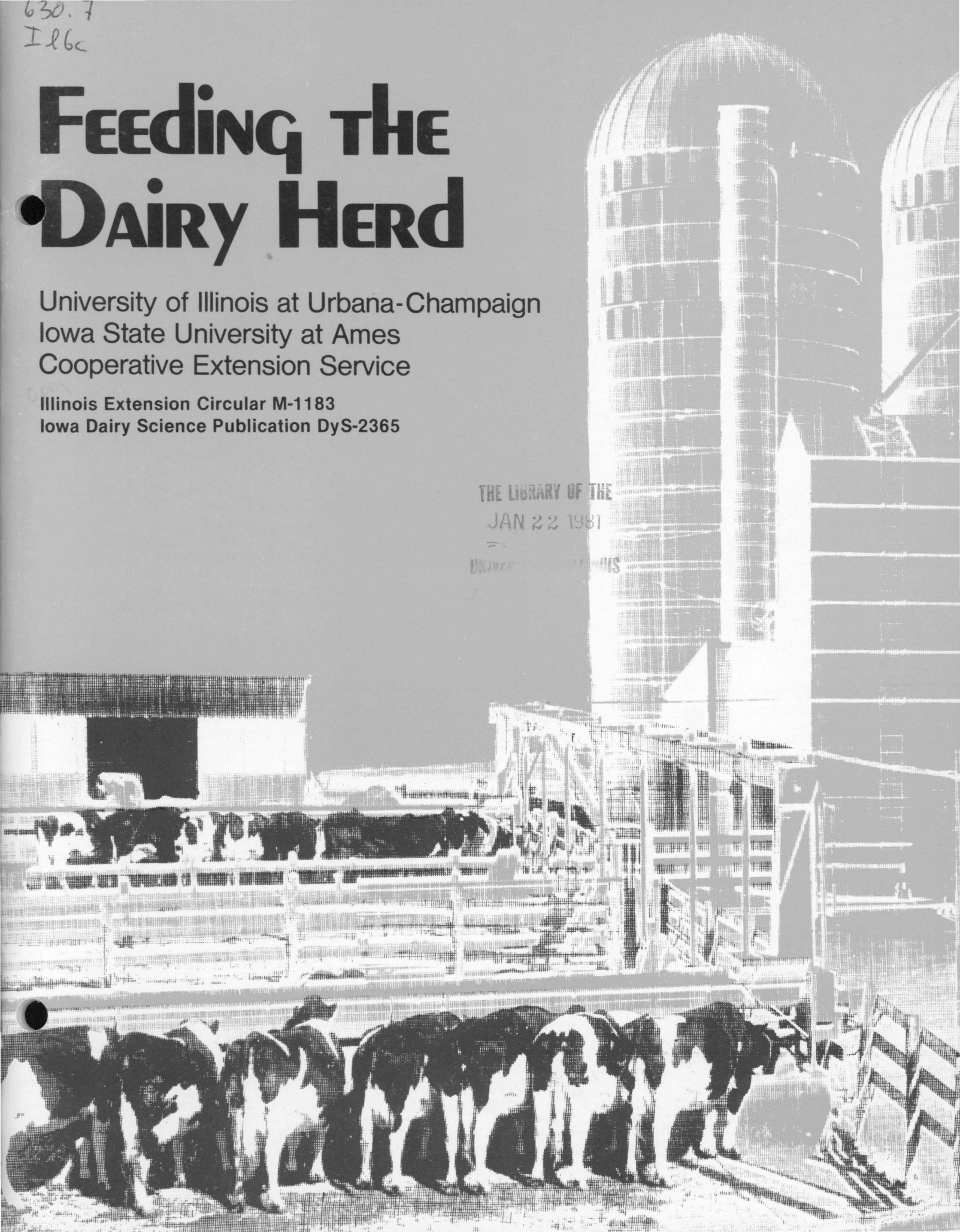
630.7
Il6c

# Feeding the Dairy Herd

University of Illinois at Urbana-Champaign
Iowa State University at Ames
Cooperative Extension Service

**Illinois Extension Circular M-1183**
**Iowa Dairy Science Publication DyS-2365**

THE LIBRARY OF THE
JAN 22 1981



## CONTENTS




THIS PUBLICATION WAS ISSUED ORIGINALLY AS UNIVERSITY OF MINNESOTA EXTENSION BULLETIN 218. THE 1981 REVISION IS REPRODUCED HERE AS UNIVERSITY OF ILLINOIS COOPERATIVE EXTENSION SERVICE CIRCULAR M-1183 AND UNIVERSITY OF IOWA DAIRY SCIENCE PUBLICATION DyS-2365. THE AUTHORS ARE J. G. LINN, D. E. OTTERBY, R. D. APPLEMAN, AND M. F. HUTJENS.


For further information and assistance, contact:


**Dr. Michael F. Hutjens**
Extension Dairyman
338 Animal Science Laboratory
University of Illinois at Urbana-Champaign
Urbana, Illinois 61801
Telephone: 217/333-2928

**Dr. Lee H. Kilmer**
Extension Dairyman
4 Kildee Hall
Iowa State University
Ames, Iowa 50011
Telephone: 515/294-2116



Issued in furtherance of Cooperative Extension Work, Acts of Congress of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture and Cooperative Extension Services in Illinois and Iowa.

The Cooperative Extension Service provides equal opportunities in programs and employment.

References to commercial products or trade names are for educational purposes only. No discrimination is intended and no endorsement by the Cooperative Extension Service is implied for specific products.



11/80—9.5M—49488—RES

Midwest dairy farms represent major capital investments in rural communities.

## RUMINANT ANATOMY AND PHYSIOLOGY

### Anatomy of the Adult

The cow's digestive tract consists of the mouth, esophagus, a complex four-compartment stomach, small intestine, and large intestine. The stomach includes the rumen or paunch, reticulum or "honeycomb," the omasum or "manyplies" and the abomasum or "true stomach" (figure 1).

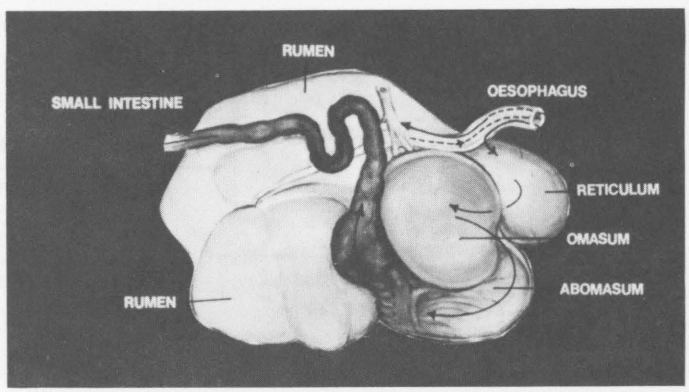
**The Rumen.** The rumen (on the left side of the animal) is the largest of four compartments and is divided into several sacs. It can hold 25 gallons or more of material depending on the size of the cow. Because of its size, the rumen acts as a storage or holding vat for feed. It is also a fermentation vat. A microbial population in the rumen digests or ferments feed eaten by the animal. Conditions within the rumen favor the growth of microbes. The rumen absorbs most of the volatile fatty acids produced from fermentation of feedstuffs by rumen microbes. Absorption of volatile fatty acids and some other products of digestion is enhanced by a good blood supply to the walls of the rumen. Tiny projections called papillae increase the surface area and the absorption capacity of the rumen.

**The Reticulum.** The reticulum is a pouch-like structure in the forward area of the body cavity. The tissues are arranged in a network resembling a honeycomb. A small fold of tissue lies between the reticulum and the rumen, but the two are not actually separate compartments. Collectively they are called the rumino-reticulum. Heavy or dense feed and metal objects eaten by the cow drop into this compartment. The reticulum lies close to the heart. Nails and other sharp objects may work into the tissue and cause "hardware disease" (see page 27). If not prevented by a magnet or corrected by surgery, infection may occur and the animal may die.

**The Omasum.** This globe-shaped structure (also called the "manyplies") contains leaves of tissue-like pages in a book. The omasum absorbs water and other substances from digestive contents. Feed material (ingesta) between the leaves will be drier than that found in the other compartments.

**The Abomasum.** This is the only compartment (also called the true stomach) with a glandular lining. Hydrochloric acid and digestive enzymes, needed for the breakdown of feeds, are secreted into the abomasum. The abomasum is comparable to the stomach of the nonruminant.

**Figure 1. Anatomy of the adult ruminant stomach.**



**The Small Intestine.** The small intestine measures about 20 times the length of the animal. It is composed of three sections: the duodenum, jejunum, and ileum. The small intestine receives the secretions of the pancreas and the gallbladder which aid digestion. Most of the digestive process is completed here and many nutrients are absorbed through the villi (small finger-like projections) into the blood and lymphatic systems.

**Cecum.** The cecum is the large area where some previously undigested fiber may be broken down. The exact significance of the cecum has not been established.

**Large Intestine.** This is the last segment of the tract through which undigested feedstuffs pass. Water is absorbed from this part of the digestive system.

## Function of the Digestive Tract

**Eructation (Belching).** Large quantities of gas, mostly carbon dioxide and methane, are produced in the rumen. Production amounts to 30-50 quarts (liters) per hour and must be removed or bloating occurs. Under normal conditions, distension from gas formation causes the cow to belch and eliminate the gas.

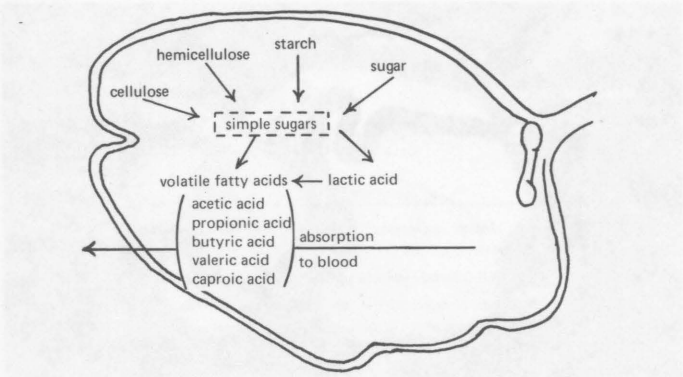
**Rumination.** A cow may spend as much as 35-40 percent of each day ruminating (cud chewing). The actual amount of time spent ruminating varies from very little (when grain or finely ground rations are fed) to several hours (when long hay is fed). Mature cattle spend little time chewing when eating. During rest periods, feed boluses (cuds) are regurgitated for rechewing to reduce particle size and for resalivation. Feed is more readily digested by rumen microbes as particle size is reduced.

**Motility of the Rumen and Reticulum.** The rumen usually is constantly contracting and moving. Healthy cows will have one to two rumen contractions per minute. The contractions mix the rumen contents, bring microbes in contact with new feedstuffs, reduce flotation of solids, and move materials out of the rumen. Lack of or a decrease in frequency of rumen movements is one way of diagnosing sick animals.

**Saliva Production.** As much as 50-80 quarts (liters) of saliva can be produced by salivary glands and added to the rumen each day. Saliva provides liquid for the microbial population, recirculates nitrogen and minerals, and buffers the rumen. Buffers help maintain the rumen at a constant pH of 6-6.5 to aid microbial population growth and avoid off-feed problems.

**Vomiting.** Cattle rarely vomit. Occasionally certain feeds will induce vomiting. Some pasture plants, usually weeds, contain alkaloids that can cause this problem. Should this condition persist, a veterinarian should be consulted.

**Figure 2. Microbial digestion of feed carbohydrate in the rumen.**




**Digestion of Energy Feeds in the Rumen.** Carbohydrates, such as the cellulose and hemicellulose of fibrous materials and starch of grains and sugars in plant cells and byproducts, are digested by rumen microbes and converted into volatile fatty acids which serve as the primary energy source in ruminants (figure 2). The volatile fatty acids consist mainly of acetic, propionic, and butyric acids. When large amounts of forage are fed, the formation of acetic acid predominates (60-70 percent of total) with lesser amounts of propionic (15-20 percent) and butyric (5-15 percent) occurring. However, when grain feeding is increased or when finely ground forages are fed, the proportion of acetic acid may decrease to 40 percent while the amount of propionic acid may increase to 40 percent. Such a change in volatile fatty acid production generally is associated with a reduction in milk fat test.

Approximately 30-50 percent of the cellulose and hemicellulose is digested in the rumen by the microbial population. Starch is degraded 50-65 percent or more depending on amount fed and how fast ingested materials move through the rumen. Most sugars are digested completely within the rumen.

The volatile fatty acids are absorbed from the rumen into the blood stream and transported to the udder and other tissues where they are used as sources of energy for maintenance, growth, reproduction, and/or milk production. The cow derives 50-70 percent of its energy from the volatile fatty acids produced in the rumen.

**Protein and Nonprotein Nitrogen Utilization in the Rumen.** Some of the protein consumed by the cow escapes breakdown in the rumen. Protein undergoing fermentation is converted to ammonia, organic acids, amino acids, and other products. Approximately 40-65 percent of the natural protein in feed is broken down. The extent of breakdown depends on solubility of the protein and resistance to breakdown. Many rumen micro-organisms require ammonia (breakdown product of protein) for growth and synthesis of microbial protein. Ammonia also may be provided from nonprotein nitrogen (NPN) such as urea, ammonium salts, nitrates, and other compounds. Rumen microbes convert the ammonia and organic acids into amino acids which are assembled into microbial protein. Excess ammonia may be absorbed from the rumen into the blood stream (see page 28). Some may pass to the lower tract for absorption. Feed protein (that escapes breakdown in the rumen) and microbial protein pass to the abomasum and small intestine for digestion and absorption.

**Vitamin Synthesis.** The rumen micro-organisms manufacture all of the B vitamins and vitamin K. Vitamin synthesis in the rumen is sufficient for growth and maintenance. Under most conditions, cattle with functioning rumens do not require supplemental B vitamins or vitamin K in the diet.

**Fat Digestion.** Limited digestion of fat occurs in the rumen. Most of it occurs in the small intestine. Rumen micro-organisms change unsaturated fatty acids into more saturated fats through the addition of hydrogen molecules. Thus, less unsaturated fat is absorbed by cows than by simple-stomached animals.

## Calf Digestive System

At birth and during the first few weeks of life, the rumen, reticulum, and omasum are undeveloped. In contrast to the mature cow, the abomasum is the largest com-

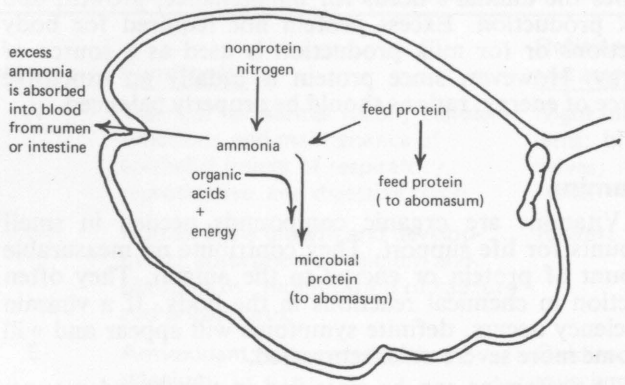



**Figure 3. Utilization of feed protein and nonprotein nitrogen in the rumen of the cow.**

partment of the stomach. At this stage of life, the rumen is nonfunctional and some feeds digested by the adult cannot be used by the calf. During nursing or feeding from a bucket, milk bypasses the rumen via the esophageal groove and passes directly into the abomasum. Reflex action closes the groove to form a tube-like structure which prevents milk or milk replacer from entering the rumen. When milk is consumed very rapidly, some may overflow into the rumen.

As long as the calf remains on milk, the rumen remains undeveloped. When grain and forage are introduced into a calf's diet, a microbial population is established and the rumen and reticulum become larger and heavier and papillae develop. End products of microbial fermentation are responsible for the development of the rumen. This occurs as early as 3 weeks of age with most feeding programs. Cud inoculation is not necessary to initiate rumen development. If hay, silage, and grain feeding is started during the first few weeks of life, the rumen will be functioning like the adult's when the calf is about 3 months of age.

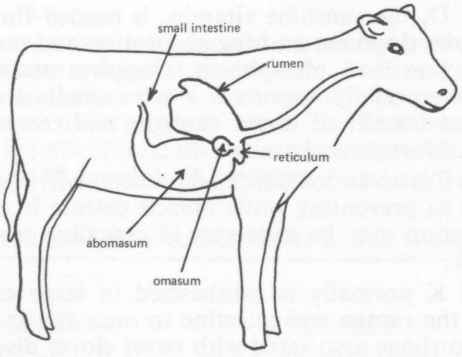



**Figure 4. Calf digestive system.**

## FEED NUTRIENTS

### Nutrients That Supply Energy

**Carbohydrates** compose the major portion of most dairy feeds and serve as the energy source. Included in this group of nutrients are sugars, starch, cellulose, and hemicellulose. Sugar is found in the cells of growing plants and in such feeds as cane or beet molasses. Starch is the main component of grains and is a source of available carbohydrate for ruminants. Cellulose and hemicellulose are made up of sugar molecules, as is starch, but are bound together differently. Cellulose and hemicellulose are classified in the fiber portion of the ration. These materials give structure and strength to plant tissues. Simple-stomach animals, such as pigs and poultry, cannot digest fiber. Adult ruminants utilize substantial fiber because rumen microbes break it down into usable products. Lignin, which is also a component of plants, is not a true carbohydrate. This compound is virtually indigestible. Feed digestibility is lowered when lignin is present in large amounts in mature forages.

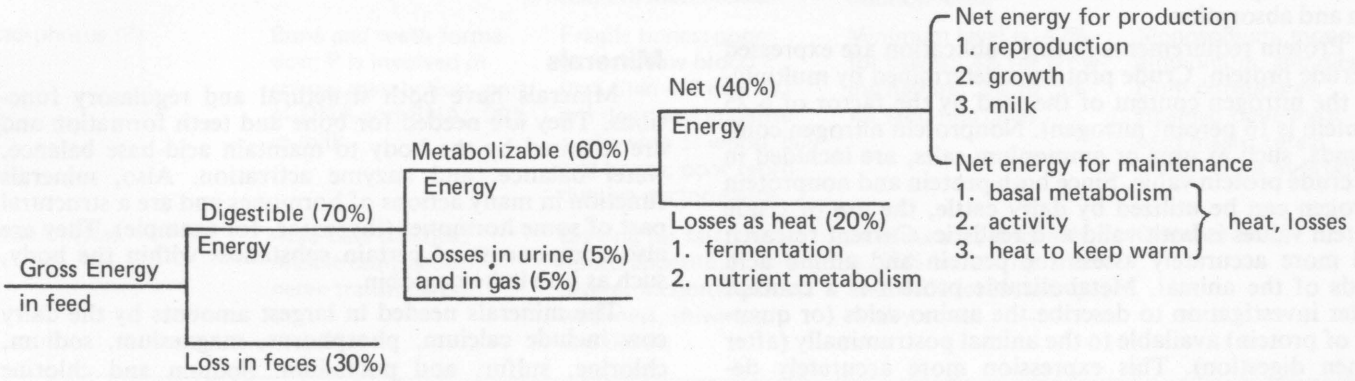
**Fat** normally is present in no more than 3-5 percent of the diet of adult ruminants. Fat in diets for calves, which include large quantities of milk or milk replacer, may amount to 10-35 percent of the dry matter consumed. It contains about 2.25 times the energy that is in carbohydrates. Fat is mainly used in diets for young calves, but occasionally is added to the diet of lactating cattle to increase energy, to reduce dustiness of feed, and to improve glossiness of hair coat in show animals. Added fat must be limited to about 5 percent since too much fat decreases feed intake and may cause scouring.

Energy (includes primarily carbohydrates and fats, but protein also can be used as energy) in a feed may be separated into:

1. the losses that occur in digestion and metabolism, and
2. the remainder that is available to the animal for maintenance and production.

Figure 5 shows this division of energy. Gross energy refers to the total energy in feed which is determined by complete

**Figure 5. Partitioning of energy and losses (60% alfalfa and 40% corn ration for a lactating cow).**



oxidation (burning) of the feedstuff and measurement of the heat produced. The energy value is then expressed as calories. Common feedstuffs often are similar in gross energy content, but differ in feeding value because of differences in digestibility. Digestible energy is gross energy minus fecal (manure) loss. These losses will be greater for high fiber rations than for low fiber rations. Other losses include those in urine and gas. In the rumen, considerable methane is produced, representing an energy loss since the animal eructates (belches). These losses, added to fecal losses, are considered in calculating the metabolizable energy. Heat is produced during digestion and metabolism. Other than during cold weather, this heat has no value and represents a further loss of energy. The remaining energy is net energy (NE) available for maintenance and production. In the requirement and feed tables for growth, a net energy value for maintenance and net energy value for gain are given. These values differ because animals use energy for maintenance more efficiently than for growth. *The efficiences of energy utilization by lactating cows for maintenance and lactation are similar. Therefore, only one net energy value is needed for these two functions.*

Total digestible nutrients (TDN) is another method of expressing the energy content of feeds or the energy requirements of cattle. TDN is comparable to digestible energy. It has been in use longer than the net energy system and more values are available for feedstuffs.

TDN = digestible nitrogen-free extract (carbohydrate) + digestible crude fiber + digestible protein + (digestible ether extract [crude fat] X 2.25)

Both NE and TDN values are given in this bulletin. However, NE values are used in calculations for the Minnesota Ration Balancer Program and in the Minnesota Dairy Herd Improvement (DHI) program.

## Protein

Protein is essential for maintenance, growth, and milk production. It is required for the formation of enzymes and certain hormones that control or regulate chemical reactions of the body. The protein requirement is really a requirement for amino acids by the animal tissues. The amino acids are supplied by the digestion of microbial protein and feed protein that escapes microbial breakdown in the rumen.

Soluble proteins are likely to be broken down into ammonia in the rumen. Insoluble proteins will be degraded to a lesser degree and pass to the abomasum and small intestine for digestion and absorption. The ammonia is used by rumen micro-organisms to form microbial protein, which also passes into the lower intestinal tract for digestion and absorption.

Protein requirements in this publication are expressed as crude protein. Crude protein is determined by multiplying the nitrogen content of the feed by the factor of 6.25 (protein is 16 percent nitrogen). Nonprotein nitrogen compounds, such as urea or ammonium salts, are included in the crude protein value. Since both protein and nonprotein nitrogen can be utilized by dairy cattle, the use of crude protein values is both valid and realistic. Current research will more accurately assess the protein and amino acid needs of the animal. Metabolizable protein is a concept under investigation to describe the amino acids (or quantity of protein) available to the animal postruminally (after rumen digestion). This expression more accurately describes the animal's needs for maintenance, growth, and milk production. Excess protein not required for body functions or for milk production is used as a source of energy. However, since protein is usually an expensive source of energy, rations should be properly balanced.

## Vitamins

Vitamins are organic compounds needed in small amounts for life support. They contribute no measurable amount of protein or energy to the animal. They often function in chemical reactions in the body. If a vitamin deficiency occurs, definite symptoms will appear and will become more severe unless corrected.

The vitamins can be classified in two broad groups: water soluble vitamins and fat soluble vitamins. Water soluble vitamins include the B vitamins: thiamine or $B_1$, riboflavin or $B_2$, niacin, pantothenic acid, pyridoxine or $B_6$, vitamin $B_{12}$, biotin, and folic acid. Choline is often included in the B complex group. Research indicates that, under usual dietary conditions, B vitamins are synthesized in sufficient amounts in the rumen to meet the animal needs. Under diseased conditions, periods of stress, or for very young animals, supplemental B vitamins may be required. Another water soluble vitamin, vitamin C (ascorbic acid), is not required by dairy cattle because they are able to synthesize it within their tissues.

Table 1 shows fat soluble vitamins (with functions, deficiency symptoms, and associated problems) in common feed sources. Vitamin A or its precursor, carotene, is needed to promote normal vision, to avoid reproductive problems, and to avoid respiratory disturbances. Carotene is found in green forages and yellow corn. Synthetic forms of vitamin A are available.

Vitamin D, the sunshine vitamin, is needed for bone growth and development and for absorption and metabolism of calcium and phosphorus. Supplementation of vitamin D is especially important when animals are confined without benefit of direct sunlight and receive primarily ensiled forages and grains.

Vitamin E is an antioxidant and prevents off-flavors in milk as well as preventing white muscle disease in calves. Supplementation may be necessary if rancidity problems occur in milk.

Vitamin K normally is synthesized in large enough amounts in the rumen and intestine to meet the animal's needs. Hemorrhage associated with sweet clover disease is caused by interference with the function of vitamin K. This problem is discussed in the herd health section.

Vitamin supplements may be available in premixes which are commonly mixed with carriers such as soybean meal or other feeds. Vitamins also are available in injectable forms.

## Minerals

Minerals have both structural and regulatory functions. They are needed for bone and teeth formation and are required by the body to maintain acid-base balance, water balance, and enzyme activation. Also, minerals function in many actions of hormones and are a structural part of some hormones (thyroxine, for example). They are also components of certain substances within the body, such as iron in hemoglobin.

The minerals needed in largest amounts by the dairy cow include calcium, phosphorus, magnesium, sodium, chlorine, sulfur, and potassium. Sodium and chlorine

**TABLE 1. SUMMARIZATION OF FAT SOLUBLE VITAMINS IN DAIRY RATIONS**

| Vitamin | Function(s) | Deficiency symptoms and associated problems | Common feed sources for dairy cattle |
|---|---|---|---|
| A | Essential for normal vision; cellular function; and maintenance of epithelial linings of respiratory, reproductive, and digestive tracts. | Night blindness; skin problems; blind, dead or weak calves; reproductive problems. | Sources of carotene: green, leafy forages; hays; haylages (little weathering); unfrosted corn silage; synthetic A; vitamin premix; fish liver oil. |
| D | Normal bone growth and development; absorption of calcium and phosphorus; mobilization of calcium and phosphorus. | Rickets, osteomalacia. | Suncured forages; fish liver oils; synthetic-premixes. |
| E | Antioxidant; associated with selenium. | Oxidized flavor in milk; muscle problems; white muscle disease; cardiac muscle abnormalities. | Alfalfa; germ of cereals; wheat germ oil; cereal grains; synthetic premixes. |
| K | Required for blood clotting. | Moldy sweet clover disease; hemorrhages. | Green, leafy forage. Ample amounts normally are synthesized in the digestive tract. |

usually are provided in the form of salt. Minerals required in small amounts (trace minerals) include iron, copper, manganese, zinc, iodine, and cobalt. Other minerals may be required in very minute amounts including molybdenum, selenium, and fluorine. Table 2 lists functions, deficiency symptoms, and feed sources of these elements. Feed tables A-9 and A-10 present the amounts of calcium and phosphorus in some common feeds. Table A-11 shows the composition of calcium and phosphorus supplements. Table A-12 gives major or macro mineral composition of some of common feeds and mineral supplements used in Minnesota.

Many commercial mineral supplements also are available. When a mineral supplement is chosen, mineral(s) needed to balance the diet should be considered. A supplement that properly meets the need should be selected. Do not choose phosphorus supplements containing less than 10 percent phosphorus. Cost per unit of the mineral needed should be the primary consideration. This can be determined by dividing the cost of the supplement (per hundred pounds or per ton) by the number of pounds of element in the supplement. (Example: 15% phosphorus ÷ $15.00 per cwt = $1 per lb. of phosphorus)

Trace mineralized salt is a common source of salt and of trace minerals. Trace mineralized salt does not contain appreciable amounts of magnesium, sulfur, or potassium. In many dairy rations these minerals are present in adequate amounts and do not require supplementation. However, if they are needed, proper supplements will have to be provided. Magnesium oxide is a common source of magnesium. Sulfur may be obtained from elemental sulfur, sodium sulfate, magnesium sulfate, or potassium sulfate. Potassium is available in potassium salts such as potassium chloride or potassium sulfate. Most commercially formulated grain mixes will contain adequate trace minerals and this information is on the feed tag.

**TABLE 2. SUMMARIZATION OF MINERALS IN THE DAIRY RATION**

| Mineral | Function(s) | Deficiency symptoms and associated problems | Recommended minimum and maximum levels | Feed sources for dairy cattle |
|---|---|---|---|---|
| Calcium (Ca) | Bone and teeth formation; blood clotting; muscle contraction. .12% in whole milk. | Rickets; slow growth and poor bone development; easily fractured bones; reduced milk yield; milk fever is a disturbance of normal calcium metabolism. | Minimum level is .60% for young calves; .4% for growing heifers; .4% to .75% for lactating cows depending on production level. | Alfalfa and other legumes; ground limestone; dicalcium phosphate; steamed bone meal. |
| Phosphorus (P) | Bone and teeth formation; P is involved in energy metabolism, part of DNA and RNA; .09% in milk. | Fragile bones; poor growth; low blood P (less than 4-6 mg/100 ml) depraved appetite — chewing of wood, hair, and bones; poor reproductive performance. | Minimum level is .42% for calves; .3% for growing heifers; .3% to .5% for lactating cows. | Monosodium, monoammonium, and dicalcium phosphates; steamed bone meal; oil seed meals; cereal grains; grain byproducts. |
| Sodium (Na) | Acid-base balance; muscle contraction; nerve transmission | Craving for salt; reduced appetite; if very severe: incoordination, weakness, shivering, and death. | Minimum level for salt is .25% for young cattle and .45% for lactating or dry cows. | Common salt |

**TABLE 2. (continued) SUMMARIZATION OF MINERALS IN THE DAIRY RATION**

| Mineral | Functions(s) | Deficiency symptoms and associated problems | Recommended minimum and maximum levels | Feed sources for dairy cattle |
|---|---|---|---|---|
| Chlorine (Cl) | Acid-base balance; maintenance of osmotic pressure; manufacture of hydrochloric acid in abomasum. | Craving for salt; reduced appetite. | (See above) | Common salt |
| Magnesium (Mg) | Enzyme activator; found in skeletal tissue and bone. | Irritability; tetany; increased excitability. | Minimum level is .07% for young calves; .16% for growing calves and dry cows; .20% for lactating cows. | Magnesium oxide; forages. |
| Sulfur (S) | Needed for rumen microbial protein synthesis especially when nonprotein nitrogen is fed; found in cartilage, tendons, etc. | Slow growth; reduced milk production; reduced feed efficiency. | Minimum recommended level is .20%; levels above .35% may reduce feed intake. | Elemental sulfur; sodium and potassium sulfates; protein supplements; legume forages. |
| Potassium (K) | Maintenance of electrolyte balance; enzyme activator; muscle function; nerve function. | Decrease in feed intake; loss of hair glossiness; lower blood and milk potassium. | Minimum recommended level is .80%. | Legume forages; potassium chloride; potassium sulfate. |
| Iodine (I) | Synthesis of thyroxine | Big neck in calves; goitrogenic substances may cause deficiency. | .5 ppm for adult cattle; .25 ppm for young cattle. Toxicity signs may appear at 50 to 200 ppm. Symptoms include excess salivation, watery nasal discharge, coughing. Safe levels are 20 ppm for young cattle; 50 ppm for adult cattle. | Iodized salt or trace mineralized salt. |
| Iron (Fe) | Part of hemoglobin; part of many enzyme systems. | Nutritional anemia. | 100 ppm in dry matter is recommended level. Safe level for cattle appears to be 400 to 1000 ppm depending on form of iron. | Forages; grains; trace mineralized salt. |
| Copper (Cu) | Needed for manufacture of hemoglobin; coenzyme. | Severe diarrhea; abnormal appetite; poor growth; coarse, bleached, or graying hair coat; osteomalacia. | 10 ppm in dry matter is recommended level. Cattle can safely tolerate 80 ppm. Toxicity symptoms include jaundice, liver damage, and death. | Widespread in feedstuffs; trace mineralized salt. |
| Cobalt (Co) | Part of vitamin $B_{12}$; needed for growth of rumen micro-organisms. | Failure of appetite; anemia; decreased milk production; rough hair coat. | Minimum level is .1 ppm of dry matter, 10 to 20 ppm is upper level. Signs of toxicity include reduced feed intake and body weight; emaciation; weakness; anemia. | Trace mineralized salt. |
| Manganese (Mn) | Growth; bone formation enzyme activator. | Delayed or decreased signs of estrus; poor conception. | Recommended level is 40 ppm for cattle. Maximum safe level is 1000 ppm. Excess interferes with iron metabolism and may induce hypomagnesia. | Widely distributed in feeds; trace mineralized salt. |

TABLE 2. (continued) SUMMARIZATION OF MINERALS IN THE DAIRY RATION

| Mineral | Function(s) | Deficiency symptoms and associated problems | Recommended minimum and maximum levels | Feed sources for dairy cattle |
|---|---|---|---|---|
| Zinc (Zn) | Enzyme activator; wound healing. | Decreased weight gains; lowered feed efficiency; skin problems; slow healing wounds; listlessness. | Minimum level is 40 ppm. Maximum safe level is not more than 500 ppm. | Forages; trace mineralized salt. |
| Fluorine (F) | Not known if it is essential for ruminants; has been shown to be essential for laboratory animals. | | Maximum safe level is 30 ppm. Severe reduction in feed intake; stiffness in legs; enlarged bones. A problem with high fluorine phosphates. | Rock phosphate mineral. |
| Selenium (Se) | Functions with certain enzymes. Associated with vitamin E. | White muscle disease in calves. Retained placenta (not clean) | Minimum level is .1 ppm. Maximum safe level is about 3 to 5 ppm. Toxicity shown by "alkali disease" or "blind staggers"; lameness; sloughed hooves. | Oil meals; alfalfa; wheat; oats; corn; amount varies with content in soil. |
| Molybdenum (Mo) | Part of the enzyme xanthine oxidase. | Loss of weight, emaciation; diarrhea. | Maximum safe level is 6 ppm. Symptoms include emaciation; intense liquid diarrhea; weakness, stiffness; hair color changes. | Widely distributed in feeds; deficiency is rarely a problem. |

Mineral excesses also should be avoided because of interaction with other minerals and possible toxicity. For example, even though copper is needed in small amounts, it can be toxic. Table 2 lists maximum levels of some minerals that can cause toxicity. Lead can cause toxicity and is a problem when stanchions and stalls are painted with lead-base paint. Such paint should be avoided in painting barn equipment and other items to which cattle may have access.

## Water

Water is required by lactating dairy cattle in very large amounts. Fresh water should always be available for cattle. Water supplies contaminated with bacteria or high in nitrates and sulfates should be avoided. The amounts of water (gallons/day) needed by cattle for growth, maintenance, pregnancy, and milk production follow.

TABLE 3. WATER INTAKE FOR DAIRY CATTLE

| Weight (lb) | Milk (lb) | Temperature (F) 40° & below | 60° | 80° |
|---|---|---|---|---|
| (Heifers) | | - - - - gallons/day - - - - | | |
| 200 | – | 2.0 | 2.5 | 3.3 |
| 400 | – | 3.7 | 4.6 | 6.1 |
| 800 | – | 6.3 | 7.9 | 10.6 |
| 1200[1] | – | 8.7 | 10.8 | 14.5 |
| (Dry cows) | | | | |
| 1400[1] | – | 9.7 | 12.0 | 16.2 |
| 1600[1] | – | 10.4 | 12.8 | 17.3 |
| (Lactating cows) | | | | |
| 1400 | 20[2] | 12.0 | 14.5 | 17.9 |
| | 60[2] | 22.0 | 26.1 | 24.7 |
| | 80[2] | 27.0 | 31.9 | 38.7 |
| | 100[2] | 32.0 | 37.7 | 45.7 |

[1] Maintenance and pregnancy.
[2] Maintenance and milk production.

# FEEDSTUFFS

## Forages

**Legume and Grass Mixtures for Hay and Low-Moisture Silage.** These forages are excellent sources of protein, carotene, calcium, and other minerals if harvested and stored properly. When grain intake is limited, cows may consume 2 1/2 to 3 percent of their weight as forage dry matter. When excellent quality legume forages are fed, protein supplementation can be reduced or eliminated.

Important considerations in harvesting these forages are the cutting date and stage of maturity. Table 4 shows changes in chemical composition. With advancing maturity, plants decrease in protein, energy, calcium, phosphorus, and dry matter digestibility while crude fiber increases. The fiber portion of the plant is mainly cell wall which consists of cellulose and lignin. Lignin is undigestible and makes the other nutrients less available.

Legumes and grasses can be harvested as wilted or low-moisture silage or as hay. Silage offers the advantages of less leaf loss, less time for field curing, and usually reduced labor in harvesting. Legume-grass silage should be put up at 30-40 percent dry matter in a bunker silo, 40-50 percent dry matter in a concrete or stave silo, and 50-60 percent in

an oxygen limiting silo. If too wet, undesirable fermentations develop and cattle eat less feed. Forage ensiled too dry does not ferment properly and can mold or heat excessively. Legume or grass silages should be chopped reasonably fine (set knives at 1/4 inch) and of proper moisture at ensiling. Rapid filling, good packing, and sealing are additional keys to good silage making.

Hay should not be baled or stacked until dry matter content is at least 80 percent. Otherwise, heating and molding can develop.

Legume or grass silages and wet hay can heat excessively and lose feeding value. Prolonged and excessive heating is detected by a brownish, carmelized appearance. It causes protein to join with carbohydrate which lowers both digestible protein and usable energy levels in the feed. Crude protein analyses do not reflect changes in available protein; therefore, a digestible protein test must be run. Heat damage, occurring in any kind of storage structure, can be avoided or reduced by keeping silos in good repair and harvesting, ensiling, and storing the crop using good management practices.

**Corn Silage.** Good corn silage contains nearly 50 percent grain. It is an excellent source of energy in dairy cattle diets. If properly made, cows will eat large amounts of this feed. Corn silage requires supplementation of protein and mineral to be balanced for high milk production.

Hybrids that yield the largest amounts of grain are generally best for silage. To attain maximum yield, corn should be harvested for silage when it has reached physiological maturity: kernels are fully dented and cells at the base of the kernel (when dissected) are black. Dry matter content should be approximately 35 percent (ear is 55-60 percent dry matter when the whole plant is 32-38 percent dry matter). Immature corn silage lower than 30-32 percent dry matter yields less total dry feed per acre. Seepage losses will occur after ensiling. If corn becomes too dry before ensiling, field losses are greater and the feed may not ensile as well (poor compaction, molding, and lower palatability).

**Sorghum Silage.** Sorghums can be used for silage in southern Minnesota (areas adapted to 95 day relative maturity or longer corn hybrids). Forage sorghum equals corn in yield, but grain sorghums usually do not yield as well as corn except during droughty conditions. Energy and intake potential is lower than that of corn silage.

**Small Grain Silages.** Oats, barley, wheat, and rye can be used for silage and provide feed, although yield per acre is usually less than corn or legume or grass silage. They should be harvested in boot stage to early milk stage for high crude protein content. Total yield of DM may be as much as 50 percent lower than at the soft dough. Peas can be included with oats to increase protein content. These crops should be wilted to 60 percent moisture before ensiling.

**Straws.** Oat, barley, and wheat straws are low in energy, proteins, minerals, and vitamins. They should be limited in rations for lactating cows and used only when additional fiber is needed. If adequately supplemented, some straw can be used for dry cows and older heifers.

**Stover.** Corn stover, properly supplemented, can be used in heifer and dry cow rations. It is low in protein and carotene (must be supplemented). Because of its low nutritive value, it is usually considered only as a "salvage" feed for milk cows.

**Pastures.** If well managed, pastures are a good source of nutrients. They have the added advantage of eliminating feed handling and manure hauling. Proper fertilization and management is necessary to maintain a good pasture. Trampling is a problem and results in nutrient wastage. Moving cattle and maintaining fences are major disadvantages.

Frequent rotations of small lots reduce the loss, but require more labor. Large herds are not handled easily in pasture situations. Additional grain is needed for high-producing cows. Forage quality and changes in available forage should be monitored and supplemented with stored forage.

**Green Chop.** Harvesting feeds by field chopping and feeding immediately has the advantage of reducing field losses. However, cutting every day can be a major problem during wet weather or during peak work periods.

**Forage Evaluation.** Forages can vary a great deal in nutrient content depending on stage of maturity, species composition, harvesting conditions, and moisture content (ensiled forages). In addition, changes during storage can alter nutrient composition. Nutrient content (table 4) can be estimated if the stage of cutting or maturity of the forage at harvest is known. A more precise value can be obtained through chemical analysis. Commercial laboratories provide chemical analyses of forages and other feedstuffs. A listing of these laboratories, their addresses, and cost estimates may be obtained from the county extension office.

Analyses for dry matter content, crude protein, and crude fiber (or acid detergent fiber) are the most useful. If heat damage has occurred in a forage during storage, a digestible protein determination should be made. This procedure combines the acid detergent fiber analysis with a determination of the nitrogen (crude protein) in the undigestible fiber fraction. Protein digestibility of legume-grass forages is usually in the 60-70 percent range. The pepsin test, a protein digesting enzyme, is also used to determine digestible protein. Crude protein analysis is useful for legume hay and haylage, since this component varies a great deal. A dry matter analysis of silage is useful in predicting dry matter intake. Fiber analyses are used to

**TABLE 4. AVERAGE COMPOSITION OF ALFALFA-GRASS MIXTURES HARVESTED IN MINNESOTA (12 LOCATIONS)**

| Cutting date[2] and stage of growth | 100 percent dry matter basis | | | |
|---|---|---|---|---|
| | Protein | Fiber | TDN[1] | ENE[1] |
| | ----- percent ------ | | | Mcal per 100 pounds |
| First cutting | | | | |
| June 2 (prebud) | 20 | 23.9 | 59.3 | 64.4 |
| June 15 (late bud; one-tenth bloom) | 17.2 | 30.4 | 54.4 | 56.2 |
| June 24 (one-half bloom) | 14.3 | 32.5 | 52.7 | 53.4 |
| July 2 (full bloom; mature) | 12.5 | 34.8 | 50.9 | 50.4 |
| Second cutting | | | | |
| 6-8 weeks regrowth | 16.7 | 30.8 | 54.1 | 55.7 |
| Third cutting | | | | |
| 5-6 weeks regrowth | 19.0 | 26.1 | 57.8 | 61.9 |

[1] TDN and ENE (estimated net energy) are calculated by formula from fiber.

[2] Dates will vary with location in the state and weather conditions (1 week earlier or later).

predict the energy value of forage. A representative sample of the feed is critical for testing. For hay, a minimum of 12 bales (18-20 optimal) should be sampled from different locations in the stack. A sampling probe or bale corer can be used to obtain the sample (usually county extension directors will have one). It is best to obtain haylage and silage samples at the time of ensiling. Three or four grab samples from a load during both the morning and afternoon filling will provide a quantity of material for mixing and further sampling later. This material should be refrigerated during storage prior to analysis to prevent deterioration and change in chemical composition. All samples should be combined and mixed well. A quart of material should be sent for testing. For further information see Agronomy Fact Sheet No. 25, Sampling and Testing Forages for Feeding Value, and Extension Folder 297, Interpreting Forage Test Results.

## Grains

The main nutrient contribution of grains is energy (yellow corn provides some carotene). Oats and barley are moderately high in crude protein. Processing grain (rolling, crimping, cracking, or grinding) increases its digestibility when fed to cows. About 30 percent of the whole grain will pass through cows intact if the grain is not processed before feeding. Breaking the seed coat increases digestion. Coarse-textured, processed grain enhances palatability and intake. Finely ground grain can lower digestibility, milk fat percent, and cause rumen acidosis. Pelleted grain is finely ground feed, not dusty, and can increase palatability and intake. Since calves chew their feed, whole grain can be fed to young calves or heifers up to 12 months of age.

**Corn and cob meal.** Corn and cob meal is a relatively high energy feed relished by cows. Although it contains 10 percent less energy than shelled corn, the added fiber (9 vs 2 percent) aids in maintaining fat test, and keeping cows on feed.

**Shelled corn.** Shelled corn, a common feed in Minnesota, is used in large amounts in formulating the grain portion of the ration. It is one of the highest energy feeds available for use in dairy rations. Where corn can be grown successfully, it is generally an economical source of energy. Because of its high caloric density, good management (determining the amount to feed, frequency of feeding, other feeds, etc.) is needed to obtain maximum consumption without causing digestive disturbances.

**Oats.** Oats contains 85 percent of the energy content of shelled corn. It is higher in crude protein, adds fiber and bulk to a grain mix, and helps maintain rumen function.

**Barley.** Barley is a crop that yields well in part of the state and is almost equal to shelled corn in energy value per unit weight. If barley is used in large amounts in dairy cattle rations, cattle should be adjusted gradually. Rolling is superior to fine grinding to maintain palatability. If the barley is finely ground, it shouldn't make up more than 50 percent of the grain ration.

**Wheat.** Wheat is not used often because price is usually too high. It is accceptable in dairy cattle rations in reasonable amounts (less than 50 percent). It is high in energy and relatively high in protein.

## Protein Supplements

**Soybean meal.** Soybean meal is the most common and usually most economical vegetable protein supplement in Minnesota. It contains over 50 percent protein on the dry matter basis. Many commercial supplements contain substantial amounts of soybean meal.

**Soybeans.** When economic conditions are favorable, ground unprocessed soybeans can be included in grain mixes for dairy cattle. They are slightly lower in protein than the meal and contain 18 percent fat. The maximum amount should not exceed 20 percent of the grain mix. Cows should be adjusted to beans gradually to avoid diarrhea and off-feed. The raw beans contain the enzyme, urease, which releases ammonia from urea. Urea and raw beans should not be used together. This is not a problem with soybean meal. Roasting or extruding is not necessary for ruminants, but can increase palatability and stability.

**Linseed meal.** Linseed meal is a product of the flax industry and is a good protein supplement (39 percent) although usually higher in price. It is used in fitting cattle for show or sale because it adds shine to the hair coat.

**Urea.** Urea is a nonprotein nitrogen (NPN) compound containing about 45 percent N. It has a protein equivalent of 281 percent (45% x 6.25) and can be used successfully to increase the crude protein content of the ration. The following guidelines apply to successful utilization of urea.

1. All dairy rations should be assessed for protein content before either supplemental NPN or natural protein is added to the diet. Protein may not be needed.
2. Feeds most successfully supplemented with NPN are high in energy, low in protein, and low in natural NPN (i.e., grains and corn silage). Drought-stricken corn silage made from heavily fertilized corn may contain considerable NPN.
3. Maximum amounts of urea to feed:
   - 1 percent urea in grain mix.
   - 0.5 percent in corn silage (10 lb/ton). If 0.5 percent is added to corn silage, the amount in the grain should be decreased. The addition of 10 lb of urea/ton of corn silage will increase the protein content from 8 percent to 11-12 percent on a dry matter basis (depending on losses incurred).
   - 0.4 to 0.5 lb urea/head/day.
4. Urea is not a palatable feed and should be mixed thoroughly into the grain mix or silage. Molasses can improve acceptability.
5. If cattle have not been fed urea previously, a 7-10 day adjustment period in which the urea is gradually increased will help to maintain feed intake and production.
6. Frequent feeding of feeds containing urea favors increased utilization.
7. High levels of urea can be toxic. Excessive intakes should be avoided (see page 28). Urea should not be top-dressed.
8. Amount of urea used should be limited in early lactation.

Urea can be used in making up a high-protein concentrate. A mixture of 100 lb of ground shelled corn and 13 lb of urea is equivalent in energy and crude protein to 100 lb of soybean meal.

A mixture of 56 lb of ground shelled corn, 7 lb of urea, and 37 lb of soybean meal also equals 100 lb of

soybean meal in total energy and protein equivalent, and can be used as a substitute for soybean meal. However, it should not be used for top-dressing grain or silage because of possible bitter feed taste and feed refusal.

**Other NPN products.** Monoammonium phosphate (used for phosphorus supplementation) contains about 11 percent nitrogen (crude protein equivalent of 68.25%). Other ammoniated products or ammonium salts are available. Ammonia (cooled to form a liquid or in a water solution) can be added successfully to corn silage at the rate of 6 lb (5lb of nitrogen) per ton. Feeding recommended amounts of urea or other NPN sources does not affect reproductive efficiency.

### Byproduct Feeds

**Brewers Grain.** The brewing industry has byproduct feeds available (dry or wet). If located near a brewery, wet brewers grains may be obtained at a reasonable cost. However, wet brewers grains contain about 80 percent water and large amounts (40-50 lb) must be fed to obtain a substantial intake of dry matter. Cattle should be adjusted to large amounts gradually. On a dry matter basis, brewers grains are high in protein and a fair source of energy.

**Wheat bran.** Bran is included to add bulk and fiber to a grain mixture. It is relatively high in protein and phosphorus, improves ration palatability, and functions as a laxative.

**Beet pulp.** Beet pulp can be obtained either in plain form or as molasses beet pulp. It is relatively high in energy, adds highly digestible fiber and bulk, enhances palatability, and can make up 30 percent of the ration dry matter.

**Screenings.** Screenings are often an economical buy. However, they *WILL* vary in protein and energy content, can be unpalatable, and in some instances can be difficult to digest.

**Malt sprouts.** Malt sprouts are high in protein and moderate in energy. They are somewhat bitter and usually are mixed with other feeds.

**Whey.** Both dried and liquid whey are available in certain areas at economical prices. Dried whey can be incorporated in grain mixtures at 10 percent of the grain mix. Dried whey also can be added to the silo at filling time at a rate of 20-100 lb per wet ton of forage. Liquid whey can be offered to cattle on a free choice basis. Because liquid whey is over 90 percent water, 15 to 25 gal need to be consumed daily to obtain substantial amounts of dry matter. Whey contains large quantities of lactose (milk sugar) and a small amount of protein and minerals. Liquid whey should not be over 36 hours old because it will become acidic and cattle will not drink. Flies can be a problem if strict sanitation is not practiced.

**Molasses.** Cane and beet molasses supply energy and are used primarily to enhance the acceptability of the ration. The amount used should be limited to 5-7 percent of the grain mix (10 percent in pelleted feeds) to maintain flow characteristic in automatic feeding equipment and to avoid undesirable rumen effects.

**Additional References**

| | |
|---|---|
| Dairy Fact Sheet 7 | Corn Silage in Dairy Cattle Rations |
| Agronomy Fact Sheet 3 | How About Oats for Silage |
| Agronomy Fact Sheet 8 | Cut Early for Quality Forage |
| Agronomy Fact Sheet 24 | Determining Moisture Content of Forages |
| Agronomy Fact Sheet 25 | Sampling and Testing Forages for Feed Value |
| Extension Folder 297 | Interpreting Forage Test Results |
| Dairy Fact Sheet 4 | Using Ureas as a Protein Substitute |

## FEEDING THE DAIRY HERD

### Dairy Cow Nutrition

Nutrient requirements vary with the stage of lactation and gestation. Figure 6 illustrates the level of milk production, dry matter intake, and change in body weight measured in Minnesota research herds during the entire lactation. Based on figure 6, four feeding periods can be defined:

- early lactation — 70 days (peak milk production) after calving (post partum)
- peak dry matter intake — 70 to 140 days (declining milk production) post partum
- mid- and late lactation — 140 to 305 days (declining milk production) post partum
- dry period — 45 to 60 days before the next lactation

Period 1. **Early Lactation** — 70 days post partum

The most critical period occurs when the cow begins to produce milk. Milk production increases rapidly, peaking at 4-6 weeks after calving. Maximum dry matter intake is reached at 12-14 weeks (period 2). Increasing grain 1-2 lb per day after calving will increase nutrient intake while minimizing off-feed problems and acidosis. Excessive levels of grain (over 65 percent of the total dry matter)

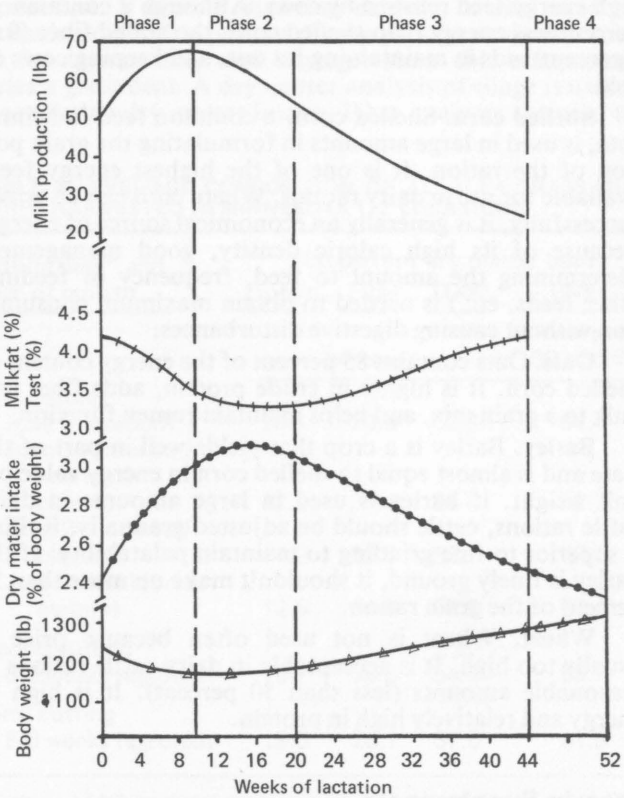



**Figure 6. Various feeding periods with milk production, dry matter intake, and body weight change curves.**

must be avoided since fiber level in the total ration should be above 15 percent to maintain rumen fermentation. Physical form of the fiber (chopped silage, long hay, pelleted grain, rolled grain) may dictate higher levels (17 percent as suggested by NRC) or lower levels (13 percent) of fiber for optimal milk production and feed efficiency. Topdressing natural protein can help meet protein needs if it is not possible to feed complete rations. Extra protein permits more efficient use of body fat for milk production since cows are usually losing body weight (negative energy balance). Feeding 1 lb of protein supplement (soybean meal, 40 percent commercial supplement, etc.) per 10 lb of milk over 50 lb of milk is one guideline. Forage quality and type will influence this guideline. Limit urea (NPN) to .4-.5 lb per day. Some research indicates urea is utilized less efficiently when total ration protein level is high.

Low peak production and ketosis problems occur when nutrient levels are not met. Low peak production is a problem if it causes low lactation production. If grain intake is increased too rapidly or is too high, off-feed, acidosis, and displaced abomasum are possible.

To increase nutrient intake:

- feed top quality forage,
- top-dress natural protein,
- increase grain intake at a constant rate after calving,
- use grains high in energy content,
- allow constant access to feed,
- minimize stress (disease, parasite infestation, etc.).

Period 2. **Peak Dry Matter Intake** — second 10 weeks post partum

Cows should be kept at peak production as long as possible. Feed intake is near maximum and approximately equal to nutrient needs (figure 6) in period 2. Grain intake can reach 2 1/2 percent of the cow's body weight (1300 lb cow consuming 32 lb of grain). Forage intake (dry matter basis) should be at least 1 percent of the cow's body weight to maintain rumen function and fat test. Feeding beet pulp, corn and cob meal, and/or molasses can encourage cows to consume high levels of grain and maintain rumen digestion.

Potential problems during this period include a rapid drop or decline in milk production, low fat test, silent heat, anestrus (no observed heat), and ketosis.

To maximize nutrient intake:

- feed forages and grain several times a day,
- feed the best quality feeds available,
- limit urea to .4 lb per cow per day,
- continue to minimize stress conditions.

Period 3. **Mid-to Late Lactation** — 140-305 days post partum

Most cows have few problems during this phase. Milk production is declining, the cow is pregnant (hopefully), and requirements are lower. Guard against wasteful grain feeding to low producers. Match grain intake to milk production. Cows that lose weight in early lactation should be fed extra nutrients to replace body reserves because cows are more efficient while lactating. Less feed is needed per pound of body tissue replaced. Do not wait until cows are dry to replace body condition. Young cows should receive additional nutrients for growth (2-year-old = 20 percent more; 3-year-old = 10 percent more).

Potential problems are few. Milk production should not drop rapidly. An 8-10 percent decline from the previous month is normal. Avoid over-conditioned cows.

Management practices include meeting the individual cow's needs, replacing lost body tissue, and keeping young cows growing. Use recommended levels of urea (.4-.5 lb/cow/day) if it is needed.

Period 4. **Dry Period** — 45-60 days before the next lactation.

Although nutrient requirements are not high, this is a critical stage for dry cows. Mistakes in the dry period can adversely affect milk yield in the next lactation. Cows need sufficient feed both to support the unborn calf and to meet body reserves not replaced in period 3. Dry matter intake is near 2 percent of body weight. Since a minimum of 1 percent of body weight must be forage, grain intake should not exceed 1 percent (especially during lead feeding) and .5 percent during the dry period. The amount of grains fed during the dry period will depend on forage quality and type. Limiting feed may be necessary (1 1/2 percent body weight as corn silage dry matter, use of corn stalks or straw, etc.). Some grain should be fed 2 weeks before calving to establish rumen microflora that digest grain (grain can be increased after calving). Calcium and phosphorus needs must be met. Avoid excessive calcium intake (over 100 grams per day) and provide minimum phosphorus needs (40 grams per day). The calcium to phosphorus ratio (with the above guideline) is approximately 2:1. Supplemental vitamins A and D (injected or fed) can improve calf survival, increase colostrum level of vitamins, and lower retained placenta and milk fever if the feed sources are low or deficient. Trace minerals, especially iodine and cobalt, should be supplemented. Iodine deficiency can result in weak calves with big necks (goiter).

Potential problems include milk fever, displaced abomasum, and fat cow syndrome. Fat cow syndrome is observed in cows carrying excessive conditioning, which causes fatty liver and poor appetite, and in cows prone to metabolic disorders and diseases.

Key management factors include:

- limiting lead feeding (increasing grain before calving) to maximum of 1 percent of the cow's body weight if at all,
- meeting nutrient needs (energy, protein, minerals, and vitamins),
- determining if any grain is needed or desirable,
- avoiding excessive energy and calcium levels.

Based on the period feeding approach, tables 5 and 6 contain suggested grain and protein guidelines. Sample rations

**TABLE 5. AMOUNT OF GRAIN TO FEED BY PERIODS (1400 LB COW, 4% MILK)**

| | Production ability of the cow (lb)[1] | | | |
|---|---|---|---|---|
| Average daily 1st period: | 50 | 60 | 80 | 90-100 |
| Lactation total: | 10,000 | 12,000 | 15,000 | 18 000 |
| | ------ Grain to milk ratio ------ | | | |
| Period of lactation | | | | |
| 1. (1st 10 weeks) | 1:4 | 1:3 | 1:3 | 1:3 |
| 2. (2nd 10 weeks) | 1:4 | 1:3 | 1:2.5 | 1:2.5 |
| 3. (Last 24 weeks) | 1:4 | 1:4 | 1:3 | 1:3 |
| 4. (Dry, 6-8 weeks) | 3-4 lb daily | 4 lb daily | 4 lb daily | 6 lb daily |
| Total grain (approximate) | 3000 lb | 4000 lb | 5000 lb | 6000 lb |

[1]Ratios based on 100 percent dry matter basis, grain containing 80 percent TDN and forage 60 percent TDN.

**TABLE 6. PROTEIN LEVELS OF TOTAL RATIONS DURING FOUR PERIODS OF LACTATION**

| | Production ability of the cow | | |
|---|---|---|---|
| Average 1st 10 weeks: | 60 lb | 80 lb | 90 lb |
| Lactation total: | 12,000 lb | 15,000 lb | 18,000 lb |
| | ----- % of ration dry matter ----- | | |
| Period | | | |
| 1. (1st 10 weeks) | 16 | 19 | 20 |
| 2. (2nd 10 weeks) | 13 | 15 | 16 |
| 3. (Last 24 weeks) | 12 | 12 | 12 |
| 4. (Dry, 6-8 weeks) | 9 | 9 | 9 |

**TABLE 7. SAMPLE RATIONS FOR COWS IN VARIOUS FEEDING PERIODS WITH VARIOUS FORAGE TYPES AND COMBINATIONS**

| Type of Forage | Period 1* | Period 2* | Period 3 | Period 4 |
|---|---|---|---|---|
| Legume forage | | | | |
| Alfalfa hay (lb) | 22 | 29 | 29 | 22 |
| Grain mix (lb) | 41 | 33 | 20 | 5 |
| Oats (lb) | 506 | 547 | 591 | 572 |
| Sh. corn (lb) | 1181 | 1277 | 1375 | 1334 |
| 44% Supp. (lb) | 276 | 140 | 0 | 0 |
| Dical. (lb) | 11 | 10 | 9 | 0 |
| Monosod. phos. (lb) | 0 | 0 | 0 | 70 |
| T.M. salt and vit (lb) | 25 | 25 | 25 | 25 |
| Corn Silage limited hay | | | | |
| Alfalfa hay (lb) | 6 | 6 | 6 | 6 |
| Corn silage (lb) | 45 | 63 | 63 | 45 |
| Grain mix (lb) | 34 | 24 | 11 | 1 |
| Oats (lb) | 409 | 368 | 320 | 572 |
| Sh. corn (lb) | 953 | 858 | 746 | 1334 |
| 44% Supp. (lb) | 579 | 710 | 871 | 0 |
| Dical. (lb) | 19 | 25 | 38 | 0 |
| Limestone (lb) | 15 | 14 | 1 | 0 |
| Monosod. phos. (lb) | 0 | 0 | 0 | 70 |
| T.M. salt and vit (lb) | 25 | 25 | 25 | 25 |
| Legume (1/2) Corn silage (1/2) | | | | |
| Alfalfa hay (lb) | 11 | 15 | 15 | 11 |
| Corn silage (lb) | 30 | 40 | 40 | 30 |
| Grain mix (lb) | 36 | 27 | 14 | 1 |
| Oats (lb) | 438 | 454 | 489 | 550 |
| Sh. corn (lb) | 1022 | 1058 | 1142 | 1284 |
| 44% Supp. (lb) | 488 | 444 | 328 | 0 |
| Dical. (lb) | 18 | 19 | 0 | 0 |
| Monosod. phos. (lb) | 0 | 0 | 16 | 141 |
| Limestone (lb) | 9 | 0 | 0 | 0 |
| T.M. salt and vit (lb) | 25 | 25 | 25 | 25 |
| Grass | | | | |
| Grass hay (lb) | 22 | 29 | 29 | 22 |
| Grain mix (lb) | 42 | 34 | 11 | 7 |
| Oats (lb) | 478 | 497 | 552 | 586 |
| Sh. corn (lb) | 1115 | 1161 | 1288 | 1366 |
| 44% Supp. (lb) | 355 | 292 | 118 | 0 |
| Dical. (lb) | 9 | 8 | 3 | 0 |
| Limestone (lb) | 18 | 17 | 13 | 23 |
| T.M. salt and vit (lb) | 25 | 25 | 25 | 25 |

Production: Period 1 =90 lb, Period 2 = 80 lb, Period 3 = 50 lb; fat test = 3.8% all periods and 1300 lb cow.
Dry matter: hay = 90%; corn silage = 33%; and grain = 88%.
Forage content (100% d.m.): alfalfa = 16% CP and 33% CF; corn silage = 8% CP and 26% CF; and grass = 12% CP and 37% CF.

* The amount of feed indicated meets the cow's needs. Cows may not be able to consume the indicated amounts in periods 1 and 2.

based on the period feeding concept are listed in table 7 for legume, grass, and corn silage forage-based rations.

### Summary

Compare your current feeding program to the following general guidelines.

1. 13-16 percent crude protein in the total ration
2. 60-70 percent TDN in the total ration (.60 to .80 M-cal net energy/lb)
3. 1.5 to 2.8 lb forage dry matter per 100 lb of body weight
4. 15 percent crude fiber (minimum)
5. 0.5-1 percent trace mineralized salt in the grain mix
6. 1 percent calcium-phosphorus supplement in the grain mix
7. No more than 5 percent molasses in the grain mix
8. Maximum of .4 to .5 lb of urea per cow per day or 1 percent urea in the grain mix
9. Adequate vitamins A and D, especially in the winter
10. Grain and forages not ground too finely

### Additional References

| | |
|---|---|
| Extension Folder 269 | Thumb Rules for Dairy Cow Feeding |
| Dairy Fact Sheet 8 | Calcium-Phosphorus Mineral for Dairy Cattle |
| Dairy Fact Sheet 12 | Vitamins for Dairy Cattle |
| Dairy Fact Sheet 11 | Feeding the Dry Cow |
| Vet Science Fact Sheet 10 | Milk Fever in Dairy Cattle |
| Vet Science Fact Sheet 11 | Ketosis in Dairy Cows |
| Pamphlet 223 | Nutrition and Reproductive Performance |

## Calf Nutrition

Colostrum fed to calves as soon after birth as possible (ideally within 15 minutes and certainly within 4 hours) protects against disease. Early feeding of colostrum is necessary because:

1. new born calves have no antibodies to provide natural protection against disease until colostrum is received.
2. calves' ability to absorb gammaglobulin (the disease protection component) is substantially reduced after 24-36 hours.
3. calves may become infected with highly pathogenic (disease-causing) bacteria immediately after birth.

Excess colostrum is a highly nutritious feed, but has little or no immunity properties (antibody protection) when the calf is more than a day old. Undiluted excess colostrum contains about a third more solids than milk or reconstituted milk replacer, and is highly digestible. Storage and subsequent use of excess colostrum is highly desirable. It may be fed fresh; frozen or stored, then thawed prior to feeding; or stored as sour (fermented) colostrum.

Naturally fermented sour colostrum sometimes becomes putrid and unfit for consumption, especially during the summer months. Several chemicals (organic acids) have been used successfully to acidify the colostrum down

to a pH of 4.6. The following acids have been used separately:

| Name of acid | Concentration | Dilution |
|---|---|---|
| Formic Acid | 0.3% by weight | 1/4 cup acid per 5 gal colostrum |
| Acetic Acid | 0.7% by weight | 1/2 cup acid per 4 1/4 gal colostrum |
| Propionic Acid | 1.0% by weight | 1 cup per 6 gal colostrum |

**Comparing Colostrum, Milk, and Milk Replacer.** Although the composition of colostrum changes rapidly after calving, the first six milkings are higher in nutrients than normal milk or reconstituted milk replacers. In comparing milk replacers with milk or colostrum, take into account variations in both replacer quality and dilution rate. Table 8 shows a comparative analysis using a high quality milk replacer at standard dilution rates.

**TABLE 8. AVERAGE COMPOSITION OF COLOSTRUM, WHOLE MILK, AND RECONSTITUTED MILK REPLACER**

| Component | First milk colostrum[1] | Pooled excess colostrum[1,2] | Whole milk[1] | Reconstituted milk replacer[3] |
|---|---|---|---|---|
| | percent | | | |
| Dry matter | 28.3 | 16.0 | 12.1 | 12.0 |
| Fat | 6.0 | 5.5 | 3.5 | 2.3 |
| Protein | 18.8 | 5.5 | 3.3 | 2.7 |

[1] Based on samples from Holstein cows.
[2] Average composition from first six milkings.
[3] One part milk replacer (24 percent protein, 20 percent fat) diluted with seven parts water.

**TABLE 9. PROTEIN SOURCES IN MILK REPLACERS**

| A. Optimum | B. Acceptable | C. Inferior |
|---|---|---|
| Skim milk powder | Chemically modified soy protein | Meat solubles |
| Buttermilk powder | Soy concentrate | Fish protein concentrate |
| Dried whole whey | Soy isolates | Distillers' dried solubles |
| Delactosed whey | | Brewer's dried yeast |
| Casein | | Oat flour |
| Milk albumin | | Wheat flour |

Milk replacers vary in quality. Study the feed tag. The best milk replacer contains at least 20 percent protein, all derived from milk products. The protein level should be 22-24 percent when chemically modified soy protein, soy isolates, or soy concentrates are used because plant proteins are less digestible than milk protein. Table 9 lists various sources of protein according to acceptability in milk replacers. Compare the protein sources listed on your milk replacer feed tag with this list.

The fat level in a good milk replacer powder should be at least 10 percent and may run as high as 30 percent. The higher fat level tends to reduce the severity of diarrhea and provides additional energy for growth. Good-quality animal fats are preferable to most plant fat sources. Soy lecithin, especially when homogenized, is another acceptable fat source and improves mixing properties of the replacer.

Carbohydrate sources that the calf can use include lactose (milk sugar) and dextrose. Two common carbohydrate sources that should be excluded from milk replacers are starch and sucrose (table sugar).

**Amount to Feed, Feeding Frequency, and Age of Weaning.** A prime consideration in raising the calf is to provide adequate dry matter for growth. For an 80-100 lb Holstein calf, 1 lb of dry matter daily from milk or milk replacer is adequate from birth to weaning at 4 weeks. Estimate the dry matter percentage in the liquid diet and dilute as necessary in relation to the total volume offered the calf (table 10 has guidelines).

Once-a-day feeding of milk-fed calves has proven successful except when calves are housed in the extreme cold or in otherwise undesirable environments. The keys to its success are keen observation to detect any sickness early, before it becomes acute, and careful feeding of adequate nutrients without overfeeding.

Early weaning usually reduces the cost of rearing a herd replacement. Many calves have been weaned successfully at 3-4 weeks of age. Only healthy calves that won't be subjected to other stress (i.e., extreme cold conditions) at the same time should be weaned before 4 weeks. Also, calves weaned at this earlier age should be offered a palatable calf starter containing slightly more protein than normal (i.e., 18 percent). Calves should be consuming at least 1 lb of starter feed daily prior to weaning.

**Preventing Calf Scours.** A number of different management practices encourage the development of scours in small calves. Avoid these if at all possible.

1. Overcrowding — provide 24 to 28 square feet of bedded area or about 20 square feet of building floor space for calves raised in confined, elevated stalls.

**TABLE 10. DILUTION RATE FOR VARIOUS LIQUID DIETS FOR CALVES FED ONCE OR TWICE DAILY**

| Type of milk (Ingredient) | % Dry matter | Once daily feeding[a] Ingredient + Water = lb dry matter daily (lb/feeding) | Twice daily feeding[a] Ingredient + Water = lb dry matter daily (lb/feeding) |
|---|---|---|---|
| 1st milk colostrum | 28 | 3.5 + 3.5 = 1.0 | 2.0 + 2.0 = 1.1 |
| Pooled excess colostrum | 16 | 6.0 + 0 = 1.0 | 3.0 + 1.5 = 1.0 |
| Whole milk, Holstein | 12 | 7.0 + 0 = 0.8 | 4.0 + 0.0 = 1.0 |
| Milk replacer | 88 | .8 + 5.0 = 0.7 | 0.5 + 3.5 = .9 |

[a] Use 75-80 percent of these amounts for Jersey or Guernsey calves.

2. Inadequate ventilation — provide a minimum of 4 air exchanges per hour in winter, 15 in summer. Avoid direct drafts on the calf.
3. Wet, damp calves — adequate bedding, good ventilation, and avoiding spraying calves with water when cleaning facilities help prevent calves from becoming chilled. Providing plenty of dry bedding in maternity stall is a must.
4. Overfeeding — irregular amounts and too much of the wrong concentration or wrong kind of liquid diets are common causes of calf scours.
5. Low resistance — vitamin A, D, and E supplementation (oral or injectible forms) immediately after birth is helpful in increasing the calf's natural resistance to scours, especially if the colostrum received may be low in vitamin A content.
6. No first-milk colostrum — don't assume the newborn calf has nursed. Forty percent of the calves born receive insufficient colostrum to be protected from the calfhood disease organisms found on the farm. Feed colostrum as soon as possible after birth (minimum of 2 quarts to Holstein; 3 pints to the smaller breed calves).
7. Dirty utensils — clean the feeding utensils thoroughly after each feeding. Store upside down to drain all water out. Small amounts of excess wash water are perfect areas for bacteria to multiply rapidly.

**Use of Electrolytes.** Early detection of sickness and prompt corrective action is important to prevent scours. When a calf has only a mild case of scours (not off-feed, not depressed, and no fever), feeding an oral electrolyte solution usually is beneficial.

A good procedure to follow is to:

1. Remove or drastically reduce the amount of milk or milk replacer offered.
2. Feed only water containing an "electrolyte" for three to six feedings, depending on how soon feces become firm. Oral electrolyte solutions can be purchased commercially or can be made by combining these kitchen cabinet ingredients:

   4 teaspoons of table salt
   3 teaspoons of baking soda
   1/2 cup of "light" corn syrup
   1 gallon of water

Frequent feeding of smaller volumes is advantageous. A 100 lb calf should consume about 5 qt (10 percent of body weight) daily.

**Starter Rations.** A good quality, palatable calf starter should be offered early (i.e., 3 days of age), and certainly by the 10th or 12th day. The best calf starters are high in energy, free of excessive fines, and contain about 16 percent protein (18 percent if calves are to be weaned before 4 weeks of age). To encourage more intake, they should consist of whole, coarsely ground, cracked, or rolled grains. Molasses (up to 5 percent of the mixture) improves palatability and minimizes fines and dust. Finely ground feeds become "pasty" and are undesirable. Whole grains, especially oats, can be fed with starter rations to calves up to 3 months of age. Calf starters should be fed until calves are about 12 weeks of age. Intake should be limited to about 3 or 4 lb per calf each day.

Many commercial calf starters are quite adequate and convenient to feed. Simple, home-mixed calf starters may be equally acceptable. Table 11 gives examples of some good rations.

**TABLE 11. EXAMPLE CALF STARTER RATIONS**

| Ingredients | Ration[a] A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| | | | lb | | | |
| Corn, coarse grind | 50 | 39 | 54 | 50 | 34 | 28 |
| Oats, rolled or crushed | 35 | | 12 | 26 | 34 | 30 |
| Barley, rolled or coarse grind | | 39 | | | | |
| Beet pulp, molasses | | | | | | 20 |
| Corn cobs, ground | | | | | 15 | |
| Wheat bran | | 10 | 11 | | | |
| Soybean meal | 13 | 10 | 8 | 17 | 15 | 15 |
| Linseed meal | | | 8 | | | |
| Molasses, liquid | | | 5 | 5 | | 5 |
| Dicalcium phosphate | 1 | 1 | 1 | 1 | 1 | 1 |
| Trace mineral salt | 1 | 1 | 1 | 1 | 1 | 1 |
| Vitamin A (I.U.) | 200,000 | 200,000 | 200,000 | 200,000 | 200,000 | 200,000 |
| Vitamin D (I.U.) | 50,000 | 50,000 | 50,000 | 50,000 | 50,000 | 50,000 |
| Total (lbs.) | 100 | 100 | 100 | 100 | 100 | 100 |
| Protein (% of D.M.) | 16 | 16 | 16 | 16 | 16 | 16 |
| Fiber (% of D.M.) | 6 | 5 | 5 | 5 | 11 | 9 |

[a]Rations A, B, C, and D recommended for calves weaned after 4 weeks of age and receiving forages.
Ration E and F recommended for calves weaned after 4 weeks and not receiving forage.

**Hay or Silage for the Young Calf.** While calves may begin nibbling on good quality hay as early as 5-10 days of age, it is not necessary to feed forages before 8 to 10 weeks of age. If forages are inconvenient because of the housing and management system, it may be desirable to incorporate a forage factor (more fiber) into the starter ration. Rations E and F (table 11) are examples of suitable rations for calves not receiving hay or silage. Corn silage should be limited before 3 months of age because of its high moisture content which can limit intake and growth.

**Additional References**

| | |
|---|---|
| Fact Sheet Dairy Husbandry 9 | Using Colostrum to Raise Dairy Calves |
| Fact Sheet Dairy Husbandry 10 | Milk Replacers in Raising Dairy Calves |
| Ext. Folder 313 | Keeping Dairy Calves Healthy |
| Fact Sheet Dairy Husbandry 15 | Portable Calf Hutch |
| MS149 | 30 by 44 foot Insulated Calf Barn |

## Heifer Nutrition

**Rearing the calf from 12 weeks-1 year.** During this period of the herd replacement's life, free-choice forage and limited grain can be fed. The protein content of the grain mix need not be as high as that of the starter. The protein content and amount of forage fed will determine the need for a protein supplement in the grain. Pasture can be used successfully in the feeding program for young heifers, but it should not be expected to supply all of the nutrients for calves in this age group. A grain mix and some stored forage are desirable for young calves on pasture. Trace mineralized salt and a calcium-phosphorus supplement can be offered free-choice if not adequately supplied in the grain mix. All calves must have access to clean fresh water.

During this stage of the feeding program, grain should be limited to about 4 lb. and certainly no more than 5 lb. per day, depending on forage quality. If necessary, limit grain to keep calves from becoming overly fat. Excessive fat can result in breeding problems and also deposit fatty tissue in the udder. Over-conditioned heifers produce less in later life than those reared on a more moderate level of nutrition.

Table 12 lists grower rations for 300-400 lb. calves. If protein content of forage is moderate (12-16 percent), little or no protein supplement will be required in the grain mix. Grain mixes prepared for the milking herd are acceptable as long as they are properly fortified with minerals and vitamins.

**Feeding program for heifers 1-2 years of age (to 1 month before parturition).** If good quality forage is available, this may be the only feed required for heifers over 1 year of age. Trace mineral salt and a calcium-phosphorus supplement are advised on a free-choice basis. Heifers should gain 1.5-1.8 lb. per day (appendix table A-5). If growth is not satisfactory, some grain should be supplied to the growing heifer. Generally, only a small amount is required. The rations in table 13 indicate the amounts to feed when various forage and grain combinations are offered to 700 lb. heifers. Heifers on good pasture require no grain or forage. As pastures mature, dry out, or are heavily grazed, supplemental feed should be provided. Heifers deficient in energy, phosphorus, or vitamin A will not exhibit estrus.

**TABLE 12. GROWER RATIONS FOR 400 LB CALVES**

Ration 1
7 lb Alfalfa-grass hay (16-18% CP)
4 lb Grain mix (9.1% CP)
- 1565 lb coarse ground shell corn
- 400 lb rolled or ground oats
- 20 lb trace mineral salt
- 10 lb monosodium phosphate
- 5 lb vitamin premix

Ration 2
6 lb Alfalfa-grass hay (11-13% CP)
5 lb Grain mix (14.1% CP)
- 1000 lb rolled barley
- 700 lb rolled oats
- 100 lb dry molasses
- 170 lb soybean meal
- 20 lb trace mineral salt
- 5 lb monosodium phosphate
- 5 lb vitamin premix

Ration 3
6 lb Grass hay (12% CP)
5 lb Grain mix (14.0% CP)
- 1475 lb corn and cob meal
- 110 lb molasses
- 365 lb soybean meal
- 10 lb limestone
- 15 lb dicalcium phosphate
- 20 lb trace mineral salt
- 5 lb vitamin premix

Ration 4
3 lb Grass hay (12% CP)
6 lb Corn silage (8% CP)
5 lb Grain mix
- 1020 lb coarse ground or rolled shell corn
- 550 lb rolled or ground oats
- 375 lb soybean meal
- 10 lb dicalcium phosphate
- 20 lb limestone
- 20 lb trace mineral salt
- 5 lb vitamin premix

**TABLE 13. RATIONS FOR 700 LB HEIFERS THAT ARE GAINING 1.6 LB PER DAY**

Ration 1
42 lb corn silage (33% DM)
2 lb grain mix
- 435 lb corn and cob meal
- 1430 lb 44% supplement
- 98 lb dicalcium phosphate
- 12 lb limestone
- 20 lb trace mineral salt
- 5 lb vitamin premix

Ration 2
50 lb sweet corn cannery silage (20% DM)
3 lb grain mix
- 412 lb corn
- 137 lb oats
- 1365 lb 44% supplement
- 33 lb dicalcium phosphate
- 27 lb limestone
- 20 lb trace mineral salt
- 5 lb vitamin premix

TABLE 13 (continued)

Ration 3
28 lb oat silage
5 lb grain mix
1963 lb corn and cob meal
12 lb limestone
20 lb trace mineral salt
5 lb vitamin premix

Ration 4
15 lb grass hay
4 lb grain mix
1975 lb corn and cob meal
20 lb trace mineral salt
5 lb vitamin premix

Ration 5
7 lb alfalfa hay
20 lb corn silage
2 lb grain mix
1815 lb corn and cob meal
125 lb 44% supplement
35 lb monosodium phosphate
20 lb trace mineral salt
5 lb vitamin premix

Ration 6
7 lb legume-grass hay
20 lb corn silage
2 lb grain mix
999 lb corn
333 lb oats
626 lb 44% supplement
18 lb monosodium phosphate
20 lb trace mineral salt
5 lb vitamin premix

Ration 7
15 lb alfalfa hay
4 lb grain mix
988 lb oats
988 lb barley
20 lb trace mineral salt
5 lb vitamin premix

Ration 8
20 lb corn stover (stalkage)
3 lb grain mix
343 lb corn and cob meal
1573 lb 44% supplement
59 lb monosodium phosphate
20 lb trace mineral salt
5 lb vitamin premix

Animal size is a more important factor than age in influencing development of the reproductive tract. Most Holstein heifers seldom show estrus before reaching 600 lb. Holstein heifers can be bred to freshen at 22 months, and weigh 1100 lbs. if fed and managed properly. Overconditioning and late breeding should be avoided.

## Veal Production

Dairy calves not selected as replacement animals can be fed for either the fancy veal or conventional veal market.

**Fancy veal** calves are marketed at 200-250 lb. (2-3 months of age). The meat must be light colored, indicating that the calves have not been fed hay or grain. The efficiency of converting milk to veal approximates 10 lb of whole milk per lb of body weight gain. Milk replacers are converted to fancy veal at the rate of about 1.3 to 1.5 lb of dry milk replacer per lb of gain. The manufacturer's directions should be followed when feeding these products. Profitable veal operations depend on: (a) a low mortality rate, (b) economical housing, (c) an abundance of inexpensive labor, and (d) an established market.

**Conventional veal** animals are raised in the same manner as feeder calves finished as beef animals.

Raising conventional veal involves the same management and feeding practices used in raising herd replacements. A good "starter" feed and milk or milk replacer normally are used from birth to 4 or 6 weeks. Then a calf grower ration and a good quality forage can be fed until the animals are about 12 weeks and weigh about 200 lb.

Requirements for a profitable operation are similar to those for raising fancy veal. The decision regarding which type of veal to raise may depend on two additional factors: (a) what the market price outlook is, and (b) whether or not the calf raiser has an abundance of grain and some high quality forage available for raising conventional veal.

Management conditions are similar to those discussed in the calf section (page16).

## Dairy Beef

It may be more profitable to feed surplus dairy calves to a marketable weight of 1000 to 1200 lb, rather than market them as vealers (200 lb), feeders (400 lb), or finishing steers (700 lb). This can be accomplished through several types of feeding programs. In areas where corn silage is the most economical feed source, it can be the only forage fed to steers between 700 lb and slaughter weight. Adding moderate amounts of grain increases rate of gain and often improves the market grade. Dairy steers can be expected to gain about 1.7 lb daily on forage and protein supplement and from 2.3 to 2.6 lb daily when grain is fed at the rate of 1 percent of body weight. When an abundance of alfalfa is available, similar results can be obtained when alfalfa replaces part of the corn silage.

Steers finished only on forage require a longer feeding period. This practice tends to increase labor and housing costs, and increases interest on borrowed capital. On small Minnesota dairy farms, the number of animals is limited and dairy steers are frequently raised with the replacement heifers on an all-forage ration. The use of the magnetic or tombstone feeder provides an opportunity to feed supplementary grain to dairy beef (in order to increase rate of gain) without over-fattening replacement heifers kept in the same pen. If dairy beef are maintained in the same pen with replacement heifers, a longer feeding period may be required to finish them properly in order to obtain a higher "grade."

When dairy beef are fed separately from replacement heifers, a corn silage-grain ration is common (table 14). Other forages and grains can be used. Growth promotants approved for finishing beef, such as monensin, should be

TABLE 14. FINISHING RATION FOR DAIRY STEERS (700 TO 1100 LB)

| Ration | Lb daily | Lb D.M. |
|---|---|---|
| Ground corn | 17.0 | 15.0 |
| Supplement | 1.0 | .9 |
| Corn silage | 18.0 | 6.3 |
| **Composition of supplement** | **Lb/ton** | |
| Shelled corn, ground | 1176 | |
| Urea | 361 | |
| Dicalcium phosphate | 94 | |
| Ground limestone | 356 | |
| Vitamin A | 50 million I.U. | |
| Vitamin D | 5 million I.U. | |

used when dairy beef are separated from the replacement heifers.

## FEEDING SYSTEMS

A profitable dairy operation depends largely on the price of milk, the production per cow, and the cost of producing milk.

Management practices leading to improved milk yields per cow offer an opportunity to reduce production costs on many farms. The sample budget (table A-1) clearly demonstrates the advantage of achieving higher production, even though total expenditures for feed may be higher.

Feed costs is the largest single expense in producing milk. Based on 1979 costs estimates, feed expenses for the cow and her replacement account for approximately 45 percent of the total. Feed cost considerations also offer the greatest opportunity for savings. Careful evaluation of the feeding system can increase production while minimizing feed costs and labor.

### Forage Systems

Forages offered to the dairy herd can be of several different types, each varying in chemical composition, moisture content, and physical form. Current trends are to feed more alfalfa haylage and corn silage. The primary reasons are convenience, ease of mechanization, reduced labor in handling bulky feeds, provide more uniform feedstuffs, increase yield per acre when compared to pasture, and lower field losses when compared to hay.

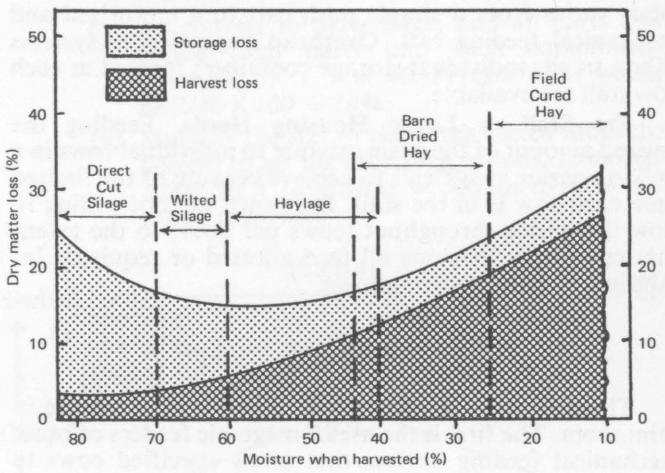



**Figure 7. Losses in legume-grass forages at various moisture levels.**

Many dairymen prefer to include some dry hay in the ration. Dry hay in the form of bales, cubes, or pellets has the advantage of being more readily transported greater distances. Alternative hay handling methods have been developed recently. Table 15 illustrates comparative advantages of each method. The large, round bales and 3-ton stacks are not easily moved a great distance, require special equipment, and are seldom utilized in stanchion barns or on farms with less than 60 cows.

Upright silos have an advantage in reduced storage losses and easily mechanized unloading. Dairymen storing more than 1,000 tons of silage annually, especially corn silage, find that bunker silos are more economical and are more reliable because they are less vulnerable to power failure or breakage of mechanical feed delivery systems. Figure 7 gives estimated harvest and storage losses when legume-grass forages are harvested at varying moisture levels and by alternative methods.

### Grain Systems

**Tie-Stall Barns.** Feeding cows housed in a tie-stall barn individually is a time-consuming, but relatively easy job. The grain mixture can include all ingredients (complete grain mix) offered except the forage, or each ingredient can be fed separately (top-dress feeding of protein supplement and/or mineral and vitamin supplement).

TABLE 15. COMPARATIVE ANALYSIS OF VARIOUS METHODS OF FEEDING DRY FORAGES

| Method of storage | Method of feeding | Losses expected | | | Hours labor required per ton to | | Tons hay required[a] |
|---|---|---|---|---|---|---|---|
| | | Harvesting | Storage | Feeding | Store | Feed | |
| | | % | % | % | | | |
| A. Conventional bales | Individually in stanchions or group fed at rack | 20 | 4 | 5 | 2.00 | 1.11 | 137 |
| B. Large round bales | Stored inside, fed in rack | 20 | 4 | 4 | 0.10 | 0.55 | 135 |
| | Stored outside, fed on ground | 20 | 11 | 22 | 0.10 | 0.40 | 166 |
| C. 3-ton stack | Stored outside, fed in rack | 20 | 9 | 4 | 0.08 | 0.24 | 135 |
| | Stored outside, fed on ground | 20 | 9 | 28 | 0.08 | 0.17 | 171 |
| D. Cubed or pelleted | Individually in stanchion or group fed at bunk | Usually purchased | 2 | 2 | (Depends on facilities & equipment) | | 130 |

[a]Tons of hay required for 50-cow herd consuming 2.5 ton per cow annually (13.7 lb daily). Additional forage from another source assumed.

Mechanical equipment available to minimize hand labor varies from a simple push cart to a motorized and mechanical feeding cart. Overhead auger feeder systems filling small, individual storage containers located at each cow stall are available.

**Free-Stall or Loose Housing Herds.** Feeding the desired amount of the grain mixture to individual cows in a milking parlor is difficult to achieve because of the limited time each cow is in the stall. Dairymen are not willing to slow the parlor throughput (cows per hour) to the extent that cows may consume all feed allotted or required. Intake in parlors varies as follows:

| | | |
|---|---|---|
| fine ground grain | = | .5 lb/min |
| coarse ground grain | = | .9 lb/min |
| pelleted grain | = | 1.3 lb/min |

Three alternative programs are gaining acceptance in Minnesota. The first is the use of magnetic feeders or other mechanical feeding devices that allow specified cows to obtain supplemental grain beyond that offered in the parlor. This system gives an opportunity to provide extra grain to selected cows when herd size or building arrangement prevents grouping cows by production level. Care must be taken, however, to prevent boss cows from eating too much grain causing digestive disturbances or a depressed fat test.

The second system involves feeding a constant amount of supplemental grain mixture with silage as it is distributed in a feed bunk. High moisture feed grains, stored in a separate silo, frequently are distributed in this manner. The primary disadvantage is that dry cows and low producers tend to consume more feed than needed. The result is that too many cows develop the "fat" cow syndrome and various metabolic conditions associated with it. Separation of cows in different groupings is advised.

Grouping cows into two or three production strings, each receiving a different level grain, is another way to achieve adequate levels of grain intake without overfeeding the lower producers. The four-stage group feeding system (fresh cows, cows at peak feed intake, cows in declining production, and dry cows) is particularly appealing to those dairymen with large herds and the physical facilities to allow such a grouping.

## Free Choice Approach to Feeding

**Forages.** Forages should be available to dairy cattle at all times. Maximum dry matter intake and optimal rumen digestion occurs when forage quality is high. Cows with no feed available for more than 3-4 hours are not on full feed.

**Lick Wheels.** Intake of urea-molasses (liquid supplements) from lick wheels usually averages from 1-2 lb per animal daily. If feed is limited, intake can increase to 5-10 lb a day and can result in urea toxicity problems. Lick wheels generally are not recommended for lactating cows with differing protein needs since cows seem unable to balance protein needs. They may have value, however, when the protein requirement of all animals in a group is uniform. Dry cows and growing heifers are two possible applications. Consider the cost of liquid supplements and do not depend on the cow's ability to balance protein needs.

**Minerals.** Dairy cattle are unable to completely balance mineral needs when offered minerals free choice. However, cattle deficient in salt and phosphorus crave these minerals and usually consume more than ample amounts on a free-choice basis. Cattle on limited fiber and/or high moisture feeds can benefit from sodium bentonite and/or sodium bicarbonate. Other methods of feeding minerals include mixing the mineral mix in the forage, grain, and/or protein supplement. Determine the type and level of mineral based on the forage type and amount, level of production, and grain program. Trace mineral salt and the correct calcium-phosphorus mineral should be force-fed and can be available free choice (for dry cows, heifers, and low-producing cows that may not receive adequate amounts from force-fed mineral sources).

## Complete Rations

Feeding complete feed rations implies that the grain mixture and all forms of forage being offered are mixed and fed together. This method of feeding has several advantages and disadvantages.

**Advantages**

- Potential for reducing the labor required to feed.
- Permits precise ration formulation.
- Use of least-cost rations.
- Provides an opportunity to easily and efficiently use urea.
- Eliminates the need to free-choice minerals.
- Insures that cows consume the desired amount of forage relative to the amount of grain offered.
- Insures that cows consume the desired proportion of forages when two or more forages are offered.

**Disadvantages**

- May be practical only in bunk feeding facility.
- Requires an additional investment (mixing facilities, weighing equipment, etc.).
- Cows with low nutrient requirements may over-eat.
- To regulate level of grain intake, grouping of cows into three or more groups is advisable.
- May be problems with "boss" cows whenever cows are grouped differently.
- Long hay cannot be incorporated unless shredded or chopped. Pellets and cubes can be used effectively.

Table A-13 shows guidelines for composition of complete feed rations (100 percent dry matter basis).

## High Moisture Grains

Feeding high moisture corn or other wet grains to dairy cattle offers these advantages.

1. Grain can be harvested 2-3 weeks earlier reducing field losses and harvest problems associated with adverse weather and it permits earlier tillage.
2. Storage and handling losses are reduced.
3. It fits automated feeding programs.
4. The expense of drying grain is eliminated.
5. Grain is highly palatable.
6. Daily labor of grain processing or grinding is reduced.

High moisture shelled corn should be stored within a moisture content range of 25-30 percent. Ground ear corn should contain 30-35 percent moisture for proper preservation. High moisture ear corn and shelled corn should be ground before storing in conventional silos. In airtight silos, the shelled corn can be stored whole or ground and rolled upon removal from the silo.

Propionic acid can be used effectively to treat and preserve high moisture corn or barley for dairy cattle. Follow specific directions on the label.

**Additional References**

| | |
|---|---|
| Animal Science Fact Sheet 22 | Use of High Moisture Corn for Dairy Cattle |
| Agronomy Fact Sheet 12 | Haylage: Low Moisture Hay-Crop Silage |
| Agronomy Fact Sheet 29 | Propionic Treated High Moisture Corn |

## RATION FORMULATION

### Method One: Quick Check on Protein Balance and Grain Feeding

A simple method to estimate the protein level needed in the grain mixture is the total 28 method as follows.

Step 1. Calculate the average protein content of all forages fed. When more than one forage is fed, a weighted average can be used (use forage test results or table A9).

| | | |
|---|---|---|
| % protein of forage (100% D.M.) | 8 | (corn silage) |
| % protein of forage (100% D.M.) | 14 | (hay) |
| Sum | 22 | |
| Average protein content of forage (100% D.M.) | 11 | |

Step 2. Calculate the average protein content needed in the grain mixture (100% D.M.)

| | |
|---|---|
| Total 28 constant* minus | 28 |
| % protein in forages equals | 11 |
| % protein needed in the grain mix | 17 |

*For high-producing cows consuming 1/2 of their ration dry matter from grain and 1/2 from forage.

Step 3. Mixing the grain ration

Once the desired level of protein is determined, calculate the proportions of homegrown grain and protein supplement needed. The box method is an accurate estimating tool. The following example shows how to formulate a grain mix of 17 percent crude protein (100% D.M.) using shelled corn (10% protein) and soybean meal (50% protein). See table A10, page 34, for other grain protein levels.

Directions:

(1) Write the desired protein level for the total grain mix in the middle of the box. *Example: 17%.*

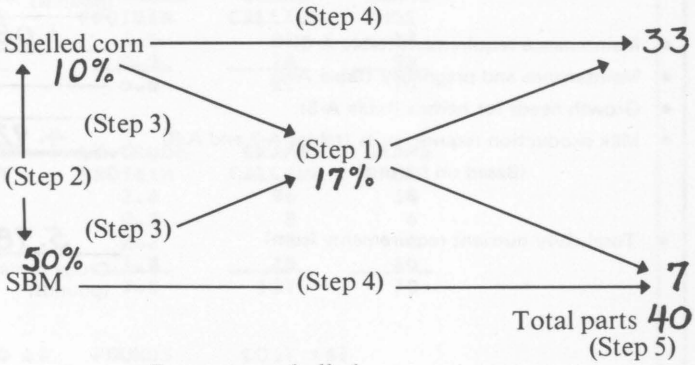
(2) Write the grain and protein supplement and their correct protein level (Table A-10) in the left corners of the square. *Example: 10% and 50%.*

(3) Subtract diagonally and write the differences in the appropriate corner. *Example: 17 - 10 = 7 and 50 - 17 = 33.* These numbers are parts or portions to mix together.

(4) Read across (horizontally) to align the parts or portions with the appropriate feed. *Example: 33 parts shelled corn and 7 parts soybean meal (SBM).*

(5) To convert to percentage, add all parts and divide total parts into each component. *Example: 33 + 7 = 40. Percent SBM would be 7/40 X 100 = 18%.*

(6) Multiply the size of the batch mixed times the percent to get the necessary pounds. *Example: 2,000 lbs X 18% SBM = 360 lbs of SMB per ton of grain mix.*




Percentage shelled corn = 33/40 X 100 = 82%
Percentage SBM = 7/40 X 100 = 18%

In this example a 1-ton mix would contain 1640 lbs of shelled corn and 360 lbs of soybean meal.

Step 4. Feeding grain according to milk production.

To meet the energy needs, feed grain according to milk production. The ration must be balanced for minerals and vitamins. Below are two guides.

- Holstein and Brown Swiss — Lbs Milk/lb Grain

| | |
|---|---|
| Less than 40 lb of milk | 4:1 |
| 40-70 lb of milk | 3:1 |
| Over 70 lb of milk | 2.5:1 |

Jersey, Guernsey, Ayrshire, and Milking Shorthorn

| | |
|---|---|
| Less than 30 lb of milk | 3:1 |
| 30-60 lb of milk | 2.5:1 |
| Over 60 lb of milk | 2:1 |

- Grain feeding according to forage quality

| Pounds milk | Good quality | | | Av. to poor quality | | |
|---|---|---|---|---|---|---|
| | Milk fat | | | Milk fat | | |
| per day | 3.5 | 4.0 | 5.0% | 3.5 | 4.0 | 5.0% |
| 20 | 0 | 1 | 2 | 11 | 12 | 13 |
| 30 | 4 | 5 | 7 | 16 | 17 | 18 |
| 40 | 8 | 10 | 12 | 20 | 21 | 24 |
| 50 | 13 | 15 | 17 | 24 | 26 | 29 |
| 60 | 17 | 19 | 22 | 28 | 31 | 34 |
| 70 | 21 | 24 | 28 | 32 | 35 | 39 |
| 80 | 25 | 28 | 33 | 37 | 40 | |

Step 5. Top-dressing protein.

For peak production in high producing cows, top-dress an additional 1 lb of protein supplement for each additional 10 lb of milk over 50 lb per day during the first 2 months of lactation (average forage quality).

**CALCULATING A BALANCED RATION FOR LACTATING DAIRY COWS**

| | |
|---|---|
| Average Weight of Cows, lbs. | 1300 |
| Milk Production, lbs. | 60 |
| Butterfat Test, % | 3.5 |

NEEDS

| | Crude protein (pounds) | Net energy (mcal) | Calcium (grams) | Phosphorus (grams) |
|---|---|---|---|---|
| • Maintenance requirement (table A-6) | 1.06 | 9.6 | 20.9 | 16.8 |
| • Maintenance and pregnancy (table A-6) | | | | |
| • Growth needs for heifers (table A-5) | | | | |
| • Milk production requirements (tables A-7 and A-8) (Based on fat test) | 4.92 | 18.6 | 71.0 | 49.0 |
| • Total daily nutrient requirements (sum) | 5.98 Crude protein (pounds) | 28.2 Net energy (mcal) | 91.9 Calcium (grams) | 65.8 Phosphorus (grams) |

INTAKE

TOTAL DAILY FEED

1300 (Cow's weight) × 3.1 (Dry feed consumption 2%-3.5% of body weight) = 40.3 (Total pounds of dry feed daily)

NUTRIENTS PROVIDED

Nutrients Proved By Daily Ration — A x 1 = crude protein; A x 2 = energy; A x 3 = calcium; A x 4 = phosphorus

| Kind of feed | A Pounds dry matter | | 1 % Crude protein | | Pounds crude protein/day | 2 Net energy milk (mcal/lb.) | | Mcal per day | 3 Calcium (grams per pound) | | Grams of calcium per day | 4 Phosphorus (grams per pound) | | Grams of phosphorus per day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 18 | × | 16 | = | 2.9 | .52 | = | 9.4 | 7.6 | = | 136 | 1.4 | = | 25 |
| Corn Silage | 6 | × | 8 | = | .5 | .72 | = | 4.3 | 1.3 | = | 8 | 1.0 | = | 6 |
| Grain | 15 | × | 13 | = | 1.9 | .84 | = | 12.6 | .2 | = | 3 | 2.0 | = | 30 |
| Protein | .9 | × | 50 | = | .5 | .89 | = | 8.0 | 1.6 | = | 1 | 3.4 | = | 3 |
| | | × | | = | | | = | | | = | | | = | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Total pounds dry feed (sum) | 39.9 | Total pounds crude protein per day (sum) | 5.8 | Total mcal for milk production per day (sum) | 34.3 | Total grams of calcium per day (sum) | 148 | Total grams of phosphorus per day (sum) | 64 |

## Method Two: Complete Hand-Calculated, Balanced Ration

Using tables A-6, A-7, A-8, A-9, A-10, and A-11, and carefully estimating feed intake, the dairy ration can be evaluated on the worksheet. Protein, energy, calcium, and phosphorus levels can be checked. If a shortage of any nutrient occurs, correct the deficiencies. Excessive nutrient levels indicate a potential source of high feed costs.

The following dairy ration should be calculated:

1. Peak production (top 10% of the cows, i.e., 70 to 80 lb. of milk)
2. Average production (average milk production plus 10 lb, i.e., 40-50 lb of milk)
3. Low producers
4. Dry cows and heifers

```
---------- MINNESOTA DAIRY RATION BALANCER ----------

TO:  JOHN DAIRYMAN                          07/08/80   PAGE 1
     RR 1                                              099001
     ANYPLACE
     MN          55108                                METHOD 4

1.  REQUIREMENTS OF 1300 LB COW PRODUCING 65 LB MILK WITH A FAT TEST OF 3.7 %:

                              M-CAL OF    LB CRUDE    GRAMS     GRAMS
                               ENERGY      PROTEIN    CALCIUM    PHOS
        MAINTENANCE --------    9.6         1.1        21        17
        MILK PRODUCTION ----   21.0         5.5        78        53
                        TOTAL  30.6         6.6        99        70

2.  RECOMMENDED FEEDING PROGRAM PROVIDES:

                              M-CAL OF    LB CRUDE    GRAMS     GRAMS
                               ENERGY      PROTEIN    CALCIUM    PHOS
        20 LB ALFALFA HAY --    7.7         2.6        96        18
        20 LB CORN SILAGE --    4.3         0.5         8         6
         5 LB 44% SUPPLEMENT    3.7         2.2         8         6
        21 LB GRAIN MIX -----  15.6         1.8        25        40
                        TOTAL  31.3         7.1       137        70

3.  YOUR GRAIN MIXTURE COULD BE:

                              COST/100 LB   POUNDS     COST ($)
        OATS ---------------     5.00         293        14.65
        CORN (SHELLED) -----     4.75         586        27.84
        CORN AND COB MEAL --     3.50         977        34.20
        MOLASSES -----------     9.00          98         8.82
        COML MINERAL (17:17)    20.00          21         4.20
        TRACE MINERAL SALT -     5.00          20         1.00
        VITAMIN PREMIX -----    24.00           5         1.20
                        TOTAL                2000 LB     $91.91

4.  FEEDING LEVEL:

        LB OF MILK (3.7%) --    10  20  30  40  50  60  70  80  90 100
        LB OF GRAIN MIX -----    0   0   5  11  15  19  23  **  **  **
        LB 44% SUPPLEMENT --     0   0   0   0   2   4   5   7   9  10

        ** - FEED GRAIN MIX FOR MAXIMUM INTAKE

5.  ADDITIONAL INFORMATION:

         8.3 % CRUDE PROTEIN IN THE GRAIN MIX
        74.3 M-CALS OF NET ENERGY / 100 LB OF GRAIN MIX
        55.5 CENTS / LB OF PROTEIN IN GRAIN MIX
        1.9 LBS DRY MATTER FROM FORAGE / 100 LB BODY WEIGHT
        0.63% CA AND .32% P IN THE TOTAL RATION
        1.9 : 1 CALCIUM TO PHOSPHORUS RATIO
        REPORTED FORAGE QUALITY---
                              % DM   % CP   % CF   ENE   % CA   % P
          ALFALFA HAY -------- 88     15     35     44   1.20   0.22
          CORN SILAGE -------- 33     08     26     65   0.28   0.20
```

Check the total dry feed intake. At high levels of grain, lower intake of forage occurs. Be realistic on dry matter intake! Dry matter intake will usually be in the following ranges (all feeds):

Dry cows: 1.5 to 2.5% of body weight

Low and average production: 2.5 to 3.0% of body weight

Peak production: 3.0 to 3.5% of body weight

## Method Three: Computerized Dairy Ration Balancer

The Minnesota Dairy Ration Balancer Program is available to all dairymen, veterinarians, feed dealers, and agri-business firms. The computer quickly and accurately balances the dairy ration for energy, protein, calcium, and phosphorus. Forage test results and customized feeding programs can be utilized. Obtain an input form from the local extension director, complete, and mail (or use teletype).

The following is an example of computer results. Recommendations for cows from 10 to 100 lb of milk are made. A small charge is made for this service. Programs are available for lactating cows, dry cows, and growing heifers.

**Additional References**

| | |
|---|---|
| Extension Folder 269 | Thumb Rules for Dairy Cow Feeding |
| Extension Folder 292 | Minnesota Dairy Ration Balancer |

## PURCHASING FEED

### Feed Tag Interpretation

Most dairymen buy some feed. It may be a complete grain mix, protein supplement, urea-molasses liquid, mineral supplement, vitamin mix, or feed additive. However, some dairymen do not know what they are buying. Is it worth $10 or $15 per hundred? What will it do?

A feed tag can give clues to these and other questions. With high feed prices, "fancy feeds" that look or sound impressive are not the best buy.

**Protein.** Protein is one nutrient which should receive close attention. The sample feed tag (figure 8) guarantees a minimum of 36 percent crude protein equivalent or 36 lb of crude protein per 100 lb of feed. If a source of nonprotein nitrogen (urea, ammonium salt, etc.) is used, it will be listed below the crude protein level as "percent equivalent crude protein from nonprotein nitrogen."

Many commercial protein supplements contain some nonprotein nitrogen (NPN), usually as urea. The amount of crude protein equivalent supplied by NPN is listed on the tag. For example, supplement XYZ contains 36 percent crude protein, of which 11.2 percent crude protein is supplied by NPN. This means that 100 lb of supplement contains 36 lb of crude protein, of which 11.2 lb of crude protein is supplied by NPN. The percent of urea in the supplement may be calculated as follows:

$$\frac{11.2}{281^*} \times 100 = 4\%$$

*Divided by 281 because urea contains 45% nitrogen. Protein contains 16 percent nitrogen. Thus, 6.25 X 45 percent nitrogen = 281 lb of crude protein equivalent in 100 lb of urea.

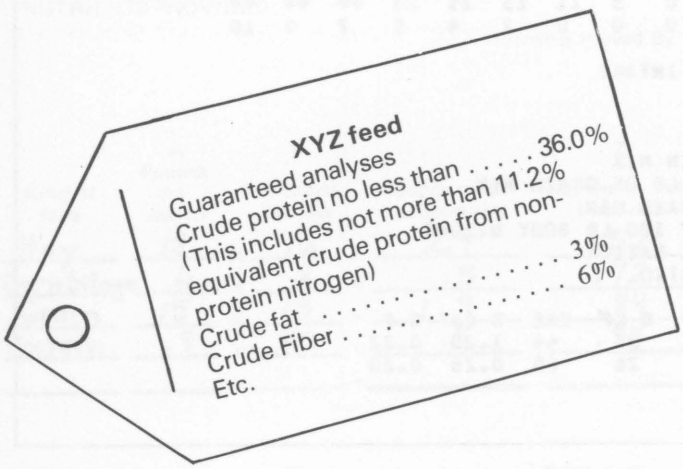



**Figure 8. Sample feed tag.**

If high producing cows are fed 4 lb of this commercial supplement daily, the cow consumes 0.16 lb of urea. This is a safe level of urea feeding (4 percent X 4 lb = 0.16 lb/cow/day).

**Fat.** Crude fat does not vary greatly in most dairy feeds except milk replacers. Fats and oils contain 2.25 times more energy than the same weight of starch or sugar (carbohydrates). Fats increase palatability and prevent dustiness, but levels above 5 percent in the total ration should be avoided. This is seldom a problem because fats and oils generally are expensive.

Animal and/or vegetable fat can be used equally well by the dairy cow. Milk production and/or fat test must increase to pay for added fat. High-producing cows that cannot consume enough grain may respond economically to added fat. Fat test may increase from 0 to .3 percent when additional fat or oil is added.

**Crude Fiber.** Crude fiber is a critical component. Since most feed tags do not list an energy value (no practical way to measure accurately), the guaranteed fiber level gives a hint.

**TABLE 16. RELATIONSHIP OF CRUDE FIBER TO ENERGY LEVEL (TDN) IN FEED**

| Feed | % Crude fiber | % TDN |
|---|---|---|
| Shelled corn | 2 | 91 |
| Ear corn | 9 | 85 |
| Barley | 6 | 83 |
| Soybean meal | 7 | 85 |
| Oats | 12 | 76 |
| Screenings (Sample A (good quality)) | 8 | 77 |
| Screenings (Sample B (fair quality)) | 18 | 61 |
| Screenings (Sample C (poor quality)) | 31 | 55 |
| Alfalfa (mid-bloom) | 31 | 56 |
| Corn cobs | 36 | 47 |

Value expressed on a 100 percent dry matter basis.

As fiber level increases, energy level is lower. Generally, for each 1 percent rise in fiber, TDN level drops about 1 percent. Fiber levels should be checked, especially in pelleted or complete dairy mixes.

**Minerals and Vitamins.** Other guaranteed nutrients, such as minerals and vitamins, should be considered when looking at a feed tag. If the feed is bought primarily for phosphorus or vitamins, calculate cost per pound or unit of that nutrient. These ingredients add nutritional value to the supplement, but they should be needed.

Feed ingredients used in making the mixture are listed below the guaranteed analysis. The percent or amount of each ingredient does not appear. It is difficult to determine how much of which feeds were used. Different amounts can be used as long as the guaranteed levels of nutrients are met.

For example, one batch of feed could contain wheat bran this week and wheat midds next week. This can affect palatability and intake but is not a problem with reputable feed companies.

**Collective Terms.** There may be collective terms on feed tags. The various groups with examples of feeds in each group follow.

*Animal protein products:* animal products (meat solubles, blood meal, etc.); marine products (fish meal); and milk products (whey, casein, etc.).

*Forage products:* alfalfa meal; corn plant silage; hay; etc.

*Grain products:* barley; corn; oats; rice; wheat; etc.

*Plant protein products:* soybean meal; sunflower meal; linseed meal; cottonseed meal; peanut meal; etc.

*Processed grain byproducts:* wheat bran; brewer's grain; flours; malt sprouts; midds, and gluten feeds or meals.

*Roughage products:* hulls (oats, barley, rice, soybeans, etc.); cobs; husks, pulps (beet, citrus, etc.); and straws.

If individual ingredients are named on the label, there is sometimes an "and/or" designation. This allows alternative ingredients for registration purposes (example: soybean meal and/or linseed meal).

## Feed Additives

Many feeds contain ingredients that are not nutrients, but function in other ways. The following is a list of common additives, their functions, and current recommendations.

| Additives | Function | Recommendation |
|---|---|---|
| Antibiotics | Reduce nutritional and environmental stress and stimulate growth response in early life. | Calves may increase weight gain 10-20 lb in the first 16 weeks of life. This improvement does not always occur. Calves may develop disease organisms resistant to the drug. No advantage is observed in older heifers or cows. Check specific product labels for level and withdrawal time. |
| Bentonite | A clay mineral which swells 5-20 times in the rumen and has adsorption properties. Adds bulk in the ration and slows the rate of feed passage. Also used as a binder in pelleting feed. | Bentonite can correct milk fat depression due to heavy grain feeding. Add 5% (100 lb per ton) in the grain mixture. Fat test will not increase above normal. Cows may consume large amounts when offered free choice. |
| EDDI (Ethylene diamine dihydroiodide) | Organic source of iodine assists in controlling foot rot and soft tissue lumpy jaw. Mechanism is not clearly understood. | Adding 50 mg/day from one source may provide the beneficial effects of organic iodine. Don't exceed 50 mg of iodine/day (not legal). |
| Fermentation byproducts | Feed additives that provide B vitamins and may influence rumen function and efficiency. | Not recommended when cows receive balanced rations and are not stressed or off-feed. |
| Formic acid | Serves as a forage preservative which acidifies the feed. | Add 1/2-1% to forage to improve preservative value. |
| Estrogenic materials (DES, etc.) | Increase the mammary gland growth in heifers, fattening, and growth. | No benefit to growing heifers; no effect on conception. Not legal for dairy cattle. |
| Kelp | Aquatic plants high in mineral content which contain trace and non-essential minerals. | No research data to warrant its addition to dairy rations. |
| Larvacide | Prevents the development of fly larvae in manure | Cattle must consume it daily. Sanitation is essential since it controls only flies that breed in manure. |
| Lecithin | Phospholipid (fat-like substance) essential in the assimilation and transport of fat and for nerve transmission | Most dairy rations contain adequate choline which is used for lecithin synthesis. Used in milk replacers to increase dispersion properties. |
| Magnesium oxide | Source of magnesium (54% by weight). Corrects milk fat depression. Increases the uptake of milk fat precursors at the mammary gland. Buffering effect in the rumen. | Milk fat depression from high grain feeding may be corrected with .4 lb/cow/day. More response occurs when combined with sodium bicarbonate. It will not raise test above normal. Magnesium oxide is unpalatable. |
| Methionine hydroxy analog | Form of the essential amino acid, methionine, which may increase milk fat test. | Milk yield responses are not consistent and would be expected only in top-producing cows. Fat test may increase when .25 to .3% analog is added to the grain mix. |
| Mineral — chelated | Mineral is chemically bound to organic matter which increases solubility and absorption. | No research to indicate increased milk production to offset high cost. |
| Monensin | Antibiotic which alters rumen fermentation increasing propionic acid and decreasing acetic acid. Improves fattening and feed efficiency in beef cattle. | This product *has not* been cleared for use in dairy cattle (July, 1980). |
| Propionic acid | Serves as a feed preservative which acidifies the feed and inhibits mold growth. Normal acid in the rumen of a cow. | Add 1/2 to 1% of the feed. Level will depend on feed moisture level and length of storage. |

| Additives | Function | Recommendation |
|---|---|---|
| Propylene glycol | Liquid or dry product converted to blood sugar in the liver of the cow. Increases circulating blood glucose (sugar). | Effective way of preventing primary ketosis by maintaining blood sugar levels. It must be administered before cows go off feed and may be unpalatable to some cows requiring drenching. Administer 8 ounces twice a day until ketones disappear from the milk (use ketone test kit). |
| Sodium bicarbonate | Neutralizes acid in the rumen and raises the rumen pH. This will change the fermentation and types of volatile fatty acids produced (more acetate and butyrate and less propionate). Normally found in saliva and buffers the rumen. | Milk fat depression from high grain feeding can be corrected to near normal when 1/2 lb/cow/day is fed. Cows may consume free choice. It can be drenched to cows that are off-feed or suffering from acidosis. Incorporate gradually. |
| Thyroxine — thyroid hormone — iodinated casein | Increase thyroid hormone levels which increase metabolic rate and processes. Milk production response may increase but varies greatly. | Not recommended to be fed since young cows did not respond; costs were greater than production increases; puts more stress on cattle, and additional feed is needed; lower efficiency. |
| Wormer (dewormer) | Prevents the growth of worms in the digestive tract which stress cattle and lower feed efficiency. | If a worm problem exists, feed the dewormer product according to label directions. Several products can be given only to nonlactating animals. |
| Yeast | Irradiated yeast is a source of vitamin D and B-complex vitamins. Changes the fermentation pattern in the rumen. | Not recommended as a feed nutrient because of cost. No advantage in adding yeast to livestock rations with sufficient B-complex vitamins. Yeast will not persist in the rumen because of acids present. Consistency of the manure may change. Brewer's dried yeast equaled linseed meal for a dairy cow supplement; dried torula yeast satisfactorily replaced soybean meal when supplied on an equal protein basis. |

## Comparing Common Feedstuffs

A method of evaluating feeds considering both energy and protein content employs the use of corn and soybean meal feed evaluation factors (table A-14 lists these factors). To evaluate any feed on the list:

1. Multiply the current price for corn by the evaluation factor for corn.
2. Multiply the current price for soybean meal by the evaluation factor for soybean meal.
3. Add the two figures.

Use the same weight units (pounds, hundredweights, tons, etc.) for corn, soybean meal, and the feed being evaluated.

Example: What is the value of corn silage on the farm when shelled corn is worth $100 and soybean meal is worth $200 per ton?

$100 X .265 = $26.50
$200 X -.011 = $-2.20 (Subtract, since this is a negative value.)
$24.30

Corn silage is worth $24.30 per ton as a feed when corn is worth $100 and soybean meal is worth $200 per ton. This comparison does not imply that the feed is balanced between energy and protein.

This method does not always indicate completely the price that should be paid for purchased feeds. For example, if a dairyman has an abundance of energy feed such as homegrown grains and silage and is interested in buying protein, he is concerned about getting the protein as cheaply as possible, with little regard for the energy it contains.

## DAIRY COW DISEASES AND DISORDERS

Good herd health management programs include:

- daily check of all animals for injury or sickness;
- handling animals quietly to prevent excitement and injury;
- consulting with a veterinarian regarding specific disease problems; and
- implementing a preventive program.

Table 17 summarizes the more common nutritional diseases and disorders. Consult the local veterinarian regarding treatment of any of these conditions. Early detection, early diagnosis, and prompt corrective treatment will keep losses at a minimum.

TABLE 17. DESCRIPTION AND PREVENTION OF DAIRY COW DISEASES AND DISORDERS

| Name | Description | Prevention |
|---|---|---|
| Acidosis (indigestion, engorgement toxemia) | The rumen may develop an acid condition (pH of 4.0 to 4.5) that impairs rumen function and digestion. The animal has a poor appetite and a dull appearance. Later, faster pulse rates may be observed together with sunken eyes and a dehydrated appearance. | Avoid accidental access or rapid changes to a high-energy feed, such as grain mixture, or too much high moisture corn. Early diagnosis and treatment are very important in severe cases to maintain life of animals. |
| Bloat | An excessive accumulation of gases in the rumen. Severe bloat occurs most commonly on newly developed, legume pastures. Breathing becomes labored and excessive salivation is common. Left side of the cow balloons. | Feed at least 10 lb dry hay before permitting grazing or recommended levels of bloat-preventing drugs. |
| Displaced abomasum (twisted stomach) | The fourth compartment of the cow's stomach moves in the body cavity after calving; it may twist, preventing passage of feedstuffs. Occurs most frequently at calving time in cows fed a high level of grain or low forage (ensiled) rations. Limited passage of feces that is more like "putty." Veterinarian's diagnosis is by detecting a "pinging" sound using a stethoscope. | Feed a minimum of 5 lb of long hay; complete feed ration preferable when high levels of grain are offered; avoid finely ground or chopped feeds. Control other diseases (mastitis, metritis, etc.). |
| Ergot | Fungus which infects the flower of cereal grain causing the seed to develop a large purplish-black growth. Ergot toxicity is due to alkaloids which can cause restricted blood flow, abortions, and reduced milk flow. | Avoid grain that contain over .06% (6 kernels in 10,000). Dilute ergot-infected feed with wholesome feed, avoid feeding to pregnant animals, and watch animals for symptoms (lameness, muscle tremors, or lower milk yield). |
| Fat cow syndrome | Cows have lowered level of liver function due to enlarged liver infiltrated with fat. Symptoms include a reduced appetite; secondary conditions may occur, such as ketosis, off feed, etc. | Feed a balanced ration (protein, minerals, and vitamins) to prevent excessive weight gain during the dry period. |
| Foot rot | A break in the skin, or hoof, usually between the toes allowing bacteria to enter. Symptoms are a rapid, progressive lameness; swollen foot; characteristic foul odor. Infection often gets into joints, spreads up the leg, and may kill the cow. | Clean yards and facilities of foreign materials that might cause a break in the skin or hoof. Soft noncallused feet on stubble or wire grass pastures are highly susceptible. Small stones lodging between the toes can also be a problem. Use organic iodine (50mg/day) and a foot bath with copper sulfate (2%). |
| Grass tetany (hypomagnesemia) | May be observed in cows on lush grass pasture high in nitrogen, resulting in low absorption of magnesium. They will suddenly develop tetany, walk with a stiff gait, fall, go into convulsions, and die. | Watch cattle closely when pasturing grass fields fertilized heavily with nitrogen. Supplementary feeding of 2 oz of magnesium oxide daily during the danger period. |
| Hardware disease (traumatic gastritis) | Results from a puncturing of reticulum by a sharp object. The animal will have a sudden lack of appetite, a reluctance to move, and a careful gait. Respiration is frequently rapid, pulse rate fast, and rectal temperature of 100° or more. | Avoid making hay or silage from fields containing old fences or recently abandoned buildings. Avoid using baling wire. Give magnets to cows if it has been a herd problem. |
| Ketosis (acetonemia) | Most frequently observed in well conditioned cows 2 to 6 weeks after calving, resulting from rapid utilization of body reserves and impaired carbohydrate metabolism. Cows refuse to eat grain, then silage, and finally hay. They gaunt up and milk production drops rapidly within a few days. | Gradually increase grain intake after calving to avoid indigestion and subsequent disease. Some hay is preferred to high silage rations. Avoid fat cows. Use propylene glycol or sodium propionate if ketosis becomes a herd problem. Early detection possible by using "kits" to test milk or urine. |
| Low fat test | Severe fat test depression (i.e., 3.8%-2.8% or less) is associated with high levels of grain feeding and/or small feed particle size. Cows usually drop in milk production and gain weight. | Increase amount and length of fiber in ration. Add bentonite at 5% to the grain ration or sodium bicarbonate at 1% (or 0.4 lb daily) to the grain ration gradually. |

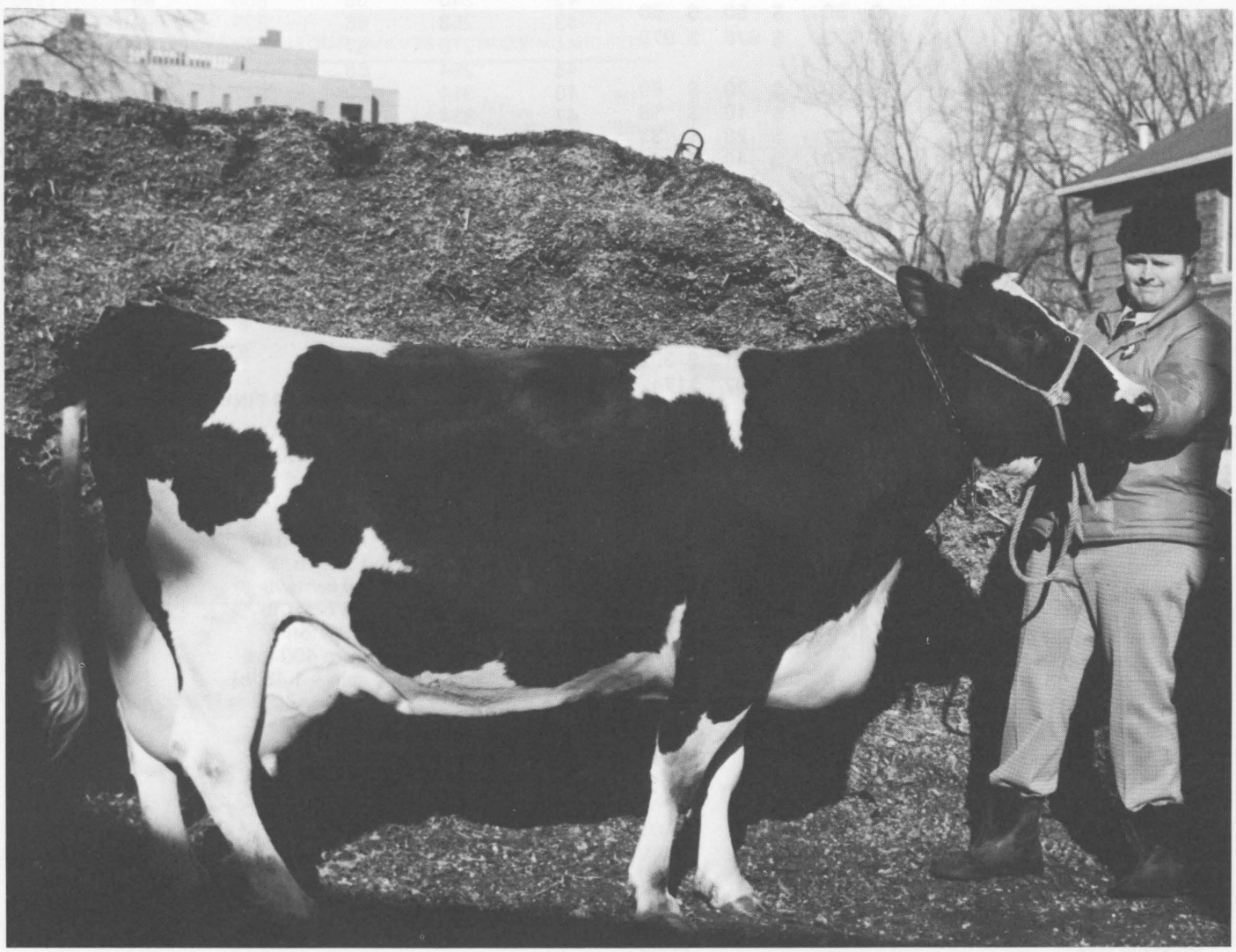
**TABLE 17. (continued) DESCRIPTION AND PREVENTION OF DAIRY COW DISEASES AND DISORDERS**

| Name | Description | Prevention |
|---|---|---|
| Mastitis | Infection of the mammary gland caused by any one of several bacterial organisms. Staphlococcus or streptococcus organisms are most frequently involved. Symptoms vary with degree of inflammation. Acute cases show a swollen and painful udder and frequently cause the cow to go off feed. Chronic cases have slightly swollen quarters and small flakes in milk. | No feed is known to cause mastitis. However, a sudden addition of high energy feeds may result in a marked increase in production and cause more stress. This, in turn, might cause subclinical mastitic cows to become clinical cases. For prevention of mastitis, consult your local veterinarian. |
| Milk fever (parturient paresis) | Occurs at calving; caused by a sudden shortage of blood calcium. First sign is staggering, difficulty in rising, and finally down and not able to rise. They are usually down with head turned back towards the flank. Delayed treatment results in death of cow or slow response to treatment. | Feed low calcium (less than 100 gms) – high phosphorus (more than 40 gms) ration during the dry period. Milk fever-prone cows can be fed a specific calcium deficient ration 4 to 10 days before calving. |
| Moldy feed toxicity (aflatoxins) | The fungus, *Aspergillis flavis,* and certain other molds, may produce toxic substances when feed grains are stored under conditions of high moisture and poor ventilation. They may also be found in standing grain during a wet harvest season. Occurrence is more common among calves (non-ruminant). They develop typical fatty liver degeneration; large adrenal glands and oversized bile ducts; reduce feed intake; have a lowered milk production; and may have a poor reproductive performance. Death in adult animals is rare. | Suspected feeds should be laboratory tested to determine if dose levels exceed 0.45 mg of aflatoxin per 100 lb of body weight. |
| Nitrite poisoning (Nitrate poisoning) | Toxicity is due to an excessive intake of nitrates or nitrites. Blood hemoglobin cannot carry oxygen to the body cells, resulting in labored breathing, frothing at the mouth, and a brownish color of the nonpigmented skin within a few hours after feeding. Abortions can occur. Death can occur within an hour in extreme cases. | Stressed plants (frost, drought, etc.) and weeds can be dangerous. Does not accumulate in grain portion of plants. Levels below 1500 ppm nitrate nitrogen are safe. |
| Prussic acid poisoning | Drought or frost-stressed hybrid sorghums or sudan grass produce toxic hydrocyanic acid. Symptoms are rapid breathing, depression, stupor, convulsions, and paralysis. Death may follow. | Avoid feeding young suckers or secondary plant growth. Silage or dry hay minimizes the risk. If an animal shows symptoms, call veterinarian immediately and remove all animals from the pasture. |
| Sweet clover poisoning | Animals hemorrhage (failure of blood to clot) resulting from sweet clover hay that has developed a white mold producing dicoumarol. Stiffness or lameness first appears 2-4 weeks after introduction of damaged sweet clover. Patches of blood under the skin may appear later. Death may occur early without warning. | Avoid feeding moldy sweet clover hay or silage. A preliminary feeding trial with only a few animals is suggested if the feed is questionable. If symptoms suggest sweet clover poisoning, call veterinarian immediately. |
| Udder edema | Edema is an excessive accumulation of lymph fluid in the udder under the skin. Usually occurs at calving and is more severe in first lactation cows. | Limiting access to either sodium or potassium salts during the dry period. Avoid excess grain. Treatmen includes stimulating circulation by massaging the udder. Diuretics should be used only under the careful scrutiny of a veterinarian. |
| Urea toxicity (Ammonia toxicity) | Too much urea at one time, or insufficient carbohydrate intake, results in excessive ammonia in the rumen. Animals show an uneasiness, muscle and skin tremors, excessive salivation, labored breathing, incoordination, and bloat. Animal urinates excessively. | No more than 0.4 lb of urea should be fed to a cow each day. (See page 11 for a more compete discussion.) |
| Winter dysentery winter scours | A scouring condition, frequent in confined cattle between November and March. It strikes suddenly; spreads rapidly, even from farm to farm. May be caused by a virus. A great volume of watery diarrhea is the main sign; feces are often bloody in color. | Isolate newly introduced animals for 2 weeks during the danger period. |

**TABLE 17. (continued) DESCRIPTION AND PREVENTION OF DAIRY COW DISEASES AND DISORDERS**

| Name | Description | Prevention |
|---|---|---|
| Chemicals<br>– Insecticides<br>– Parasiticides<br>– Herbicides<br>– Pesticides | Occasionally cattle have been contaminated with chlorinated hydrocarbon compounds such as DDT, dieldren, heptachlor, PCB's or plasticizers, PBB, etc. These compounds are fat soluble; collect in the body fat deposits; and eventually are excreted in milk. Dairymen must be very cautious about feeds that could be contaminated either by direct application or drift from aerial application. Avoid using any chlorinated hydrocarbon as an insecticide on or around dairy cattle. Always follow directions on label of insecticides, herbicides, wormers, etc. Consult with veterinarian, extension director, or sales personnel before using a product if there are any questions about its use. | |
| Poison plants | Several hundred plants are known to be toxic to livestock under certain conditions. Fortunately, cattle that consume adequate amounts of other feeds will seldom eat enough of a poisonous plant to do any harm. However, cattle will eat whatever is available when feed is scarce, consuming enough of a toxic plant to produce toxic or even fatal effects. Bracken fern, algae, and night shade are common poisonous plants in Minnesota. | |

**Avoid dry cows that carry excess body condition (thick, patchy, or fat).**



# APPENDIX

**TABLE A-1. SAMPLE BUDGET OF COSTS AND RETURNS FOR A MILK COW AND HER REPLACEMENT AT THREE DIFFERENT LEVELS OF PRODUCTION. (NOTE: REPLACEMENT ANIMALS ARE BASED ON A 30 PERCENT CULL RATE; TOTAL COSTS ARE APPROXIMATELY $175.)**

| | Level of production (lbs) | | |
|---|---|---|---|
| | 12000 | 14000 | 16000 |
| Income | | | |
| Milk, @ $12.00/cwt. | $1440 | $1680 | $1920 |
| Cull cow & calf sales | 290 | 320 | 350 |
| Total Income | $1730 | $2000 | $2270 |
| Feed costs | | | |
| Corn equiv. (bushels) | (60) | (90) | (120) |
| @ $2.75/bu. | $ 165 | $ 248 | $ 330 |
| Protein (cwt.) | (4) | (6) | (8) |
| @ $10/cwt. | $ 40 | $ 60 | $ 80 |
| Corn silage, 11.5T @ $20 | $ 230 | $ 230 | $ 230 |
| Hay Equiv., 4.8T @ $60 | $ 288 | $ 288 | $ 288 |
| Milk replacer, calf starter, salt and minerals | $ 50 | $ 50 | $ 50 |
| Total feed cost | $ 773 | $ 876 | $ 978 |
| Other costs | | | |
| Milk hauling @ .50/cwt. | $ 60 | $ 70 | $ 80 |
| Breeding fees | $ 14 | $ 16 | $ 18 |
| Vet. med. & drugs | $ 22 | $ 28 | $ 33 |
| Bedding | $ 40 | $ 40 | $ 40 |
| Supplies, utilities, and records | $ 110 | $ 115 | $ 120 |
| Equipment, fuel and repairs | $ 81 | $ 81 | $ 81 |
| Total, other costs | $ 327 | $ 350 | $ 372 |
| Labor cost, 65 hrs. @ $3.25 | $ 211 | $ 211 | $ 211 |
| Management value, 8% of income | $ 138 | $ 160 | $ 182 |
| Labor and management costs | $ 349 | $ 371 | $ 392 |
| Total costs | $1449 | $1597 | $1742 |
| Return to facilities, livestock, and risk | $ 281 | $ 403 | $ 528 |

**TABLE A-2. SAMPLE BUDGET FOR RAISING REPLACEMENT HEIFERS TO 1170 LBS IN 24 MONTHS**

| | Example costs |
|---|---|
| | $ |
| Feed Costs | |
| Milk replacer, 40 lb @ 45 cents/lb | 18.00 |
| Calf starter, 90 lb @ 10 cents/lb | 9.00 |
| Calf grower, 130 lb @ 9 cents/lb | 11.70 |
| Grain mix, 338 lb @ 8¼ cents/lb | 27.80 |
| Hay equiv., 5.2T @ $60/ton | 312.00 |
| Total feed costs | $378.50 |
| Other costs | |
| Original value of calf | 150.00 |
| Labor, 30 hrs. @ 3.25 | 97.50 |
| Housing and equip. costs | 100.00 |
| Bedding costs | 40.00 |
| Vet. med. and drugs | 20.00 |
| Breeding fees | 14.00 |
| Supplies and utilities | 25.00 |
| Equipment, fuel, and repairs | 25.00 |
| Total, other costs | $471.50 |
| Total | $850.00 |

**TABLE A-3. ESTIMATING WEIGHT OF DAIRY ANIMALS ON BASIS OF HEART GIRTH MEASUREMENTS**

| Heart girth inches | Weight lbs. | Heart girth inches | Weight lbs. | Heart girth inches | Weight lbs. |
|---|---|---|---|---|---|
| 26 | 80 | 49 | 374 | 72 | 1069 |
| 27 | 84 | 50 | 394 | 73 | 1111 |
| 28 | 89 | 51 | 414 | 74 | 1153 |
| 29 | 95 | 52 | 434 | 75 | 1197 |
| 30 | 101 | 53 | 456 | 76 | 1241 |
| 31 | 108 | 54 | 478 | 77 | 1285 |
| 32 | 118 | 55 | 501 | 78 | 1331 |
| 33 | 128 | 56 | 526 | 79 | 1377 |
| 34 | 138 | 57 | 552 | 80 | 1423 |
| 35 | 148 | 58 | 579 | 81 | 1469 |
| 36 | 158 | 59 | 607 | 82 | 1515 |
| 37 | 168 | 60 | 637 | 83 | 1561 |
| 38 | 180 | 61 | 668 | 84 | 1607 |
| 39 | 192 | 62 | 700 | 85 | 1659 |
| 40 | 208 | 63 | 732 | 86 | 1712 |
| 41 | 224 | 64 | 766 | 87 | 1764 |
| 42 | 240 | 65 | 800 | 88 | 1816 |
| 43 | 258 | 66 | 835 | 90 | 1868 |
| 44 | 276 | 67 | 871 | 91 | 1921 |
| 45 | 294 | 68 | 908 | 92 | 1975 |
| 46 | 314 | 69 | 947 | | |
| 47 | 334 | 70 | 987 | | |
| 48 | 354 | 71 | 1027 | | |

Measure animal with steel carpenter's tape or a heavy nonstretchable tape. Place tape just behind front legs and behind shoulders and pull up snug.

**TABLE A-4. SAMPLE BUDGET FOR FINISHED DAIRY BEEF TO 1100 LBS IN 17 MONTHS**

Feeder calves (90 to 400 lbs in 125 days)

| | Example costs |
|---|---|
| | $ |
| Feed costs | |
| Milk replacer, 40 lb @ 45 cents/lb | 18.00 |
| Calf starter, 90 lb @ 10 cents/lb | 9.00 |
| Calf grower, 130 lb @ 9 cents/lb | 11.70 |
| Grain mix, 450 lb @ 8¼ cents/lb | 37.15 |
| Hay equiv., 650 lb @ $60/ton | 19.50 |
| Feed costs (birth to 400 lbs) (Average daily gain = 1.45 lb) | 93.35 |
| Nonfeed costs | |
| Original value of calf | 80.00 |
| Nonfeed cash costs | 16.00 |
| Labor, 5 hrs. @ $3.25/hr. | 16.25 |
| Death loss, 15% of ½ of above | 15.60 |
| Interest on investment, 8% of ½ of above | 8.30 |
| Total costs (birth to 400 lbs) (Cost/lb = 57.9 cents) | 231.50 |
| Feeder yearlings (400 to 700 lbs in 170 days) | |
| Feed costs | |
| Grain mix, 900 lb @ 8¼ cents/lb | 74.25 |
| Hay equiv., 1850 lb @ $60/ton | 55.50 |
| Feed costs (400 to 700 lb) (Average daily gain = 1.75 lb) | 129.75 |

**TABLE A-4 (continued)**

| | Example costs |
|---|---|
| Nonfeed costs including labor @ 30 cents/day | 51.00 |
| Total costs (400 to 700 lbs) | 180.75 |
| Value of 400 lb feeder calf | 231.50 |
| Total costs (birth to 700 lbs) | 412.25 |
| (Cost/lb = 58.9 cents) | |
| Finishing steers (700 to 1100 lbs in 130 days) | |
| Feed costs | |
| Grain mix, 2200 lb @ 8¼ cents/lb | 181.50 |
| Protein supplement, 130 lb @ 10 cents/lb | 13.00 |
| Corn silage, 2400 lb @ $20/ton | 24.00 |
| Feed costs (700 to 1100 lbs) | 218.50 |
| (Average daily gain = 3.0 lb) | |
| Nonfeed costs, including labor @ 30 cents/day | 39.00 |
| Total costs (700 to 1100 lbs) | 257.50 |
| Value of 700 lb finishing steer | 412.25 |
| (Cost/lb @ 60.9 cents) | 669.75 |

**TABLE A-5. DAILY NUTRIENT REQUIREMENTS OF GROWING HEIFERS**

| Body weight (lb) | Daily gain (lb) | Protein Total (lb) | $NE_m$ (Mcal) | $NE_{gain}$ (Mcal) | TDN (lb) | Ca (gm) | P (gm) | Vitamin A (1000 IU) |
|---|---|---|---|---|---|---|---|---|
| Growing heifers (large breeds) | | | | | | | | |
| 90 | .9 | .33 | 1.2 | .70 | 1.7 | 8.2 | 5.0 | 1.8 |
| 100 | 1.2 | .44 | 1.4 | 1.00 | 2.5 | 8.2 | 5.9 | 1.9 |
| 125 | 1.2 | .52 | 1.9 | 1.10 | 2.9 | 11.8 | 7.0 | 2.4 |
| 150 | 1.4 | .64 | 2.0 | 1.20 | 3.4 | 14.1 | 7.7 | 2.9 |
| 200 | 1.6 | .85 | 2.3 | 1.50 | 4.3 | 17.2 | 9.1 | 3.8 |
| 300 | 1.6 | 1.04 | 3.1 | 1.70 | 5.7 | 18.6 | 11.3 | 5.8 |
| 400 | 1.6 | 1.30 | 3.8 | 1.90 | 7.1 | 20.4 | 13.6 | 7.7 |
| 500 | 1.6 | 1.47 | 4.5 | 2.20 | 8.4 | 22.7 | 16.3 | 9.6 |
| 600 | 1.6 | 1.61 | 5.2 | 2.40 | 9.6 | 23.6 | 17.2 | 11.5 |
| 700 | 1.6 | 1.74 | 5.8 | 2.50 | 10.5 | 24.5 | 18.1 | 13.5 |
| 800 | 1.6 | 1.85 | 6.4 | 2.70 | 11.5 | 25.8 | 19.0 | 15.4 |
| 900 | 1.6 | 1.92 | 7.0 | 2.80 | 12.3 | 26.3 | 20.4 | 17.3 |
| 1000 | 1.4 | 1.97 | 7.6 | 2.60 | 12.6 | 27.2 | 20.9 | 19.2 |
| 1100 | 1.2 | 1.99 | 8.1 | 2.30 | 12.8 | 27.2 | 20.9 | 21.2 |
| 1200 | .8 | 2.01 | 8.7 | 1.60 | 12.5 | 27.2 | 20.0 | 23.1 |
| 1300 | .4 | 1.88 | 9.2 | .82 | 11.5 | 24.5 | 18.1 | 25.0 |
| Growing heifers (small breeds) | | | | | | | | |
| 55 | .7 | .25 | .8 | .5 | 1.2 | 5.9 | 4.1 | 1.0 |
| 65 | .8 | .28 | .9 | .6 | 1.4 | 6.4 | 4.5 | 1.2 |
| 100 | .8 | .36 | 1.4 | .7 | 2.2 | 9.1 | 5.9 | 1.9 |
| 125 | 1.0 | .48 | 1.6 | .9 | 2.8 | 10.9 | 6.6 | 2.4 |
| 150 | 1.2 | .59 | 1.8 | 1.1 | 3.3 | 12.7 | 7.2 | 2.9 |
| 200 | 1.2 | .75 | 2.3 | 1.1 | 3.9 | 15.4 | 8.2 | 3.8 |
| 300 | 1.2 | .96 | 3.1 | 1.2 | 5.2 | 16.8 | 10.4 | 5.8 |
| 400 | 1.2 | 1.22 | 3.8 | 1.4 | 6.6 | 19.5 | 13.1 | 7.7 |
| 500 | 1.2 | 1.41 | 4.5 | 1.6 | 7.8 | 21.8 | 15.4 | 9.6 |
| 600 | 1.2 | 1.56 | 5.2 | 1.8 | 8.9 | 22.7 | 16.3 | 11.5 |
| 700 | 1.0 | 1.67 | 5.8 | 1.6 | 9.5 | 23.1 | 16.8 | 13.5 |
| 800 | .6 | 1.58 | 6.4 | 1.0 | 9.1 | 21.8 | 16.3 | 15.4 |
| 900 | .4 | 1.51 | 7.0 | .7 | 8.9 | 20.4 | 15.9 | 17.3 |
| 1000 | .4 | 1.60 | 7.6 | .7 | 9.6 | 22.2 | 18.1 | 19.2 |

**TABLE A-6. DAILY NUTRIENT REQUIREMENTS OF LACTATING DAIRY COWS**

| Body weight (lb) | Crude protein (lb) | $NE_L$ Lactation (Mcal) | TDN lb | Ca g | P g | Vitamin A (1,000 IU) |
|---|---|---|---|---|---|---|
| Maintenance of mature lactating cow[a] | | | | | | |
| 700 | .71 | 6.0 | 5.8 | 12.7 | 10.4 | 24 |
| 800 | .77 | 6.6 | 6.4 | 14.5 | 11.8 | 28 |
| 900 | .83 | 7.3 | 7.0 | 15.9 | 12.7 | 31 |
| 1000 | .89 | 7.9 | 7.6 | 17.2 | 13.6 | 35 |
| 1100 | .95 | 8.4 | 8.2 | 18.1 | 14.5 | 38 |
| 1200 | 1.01 | 9.0 | 8.8 | 19.5 | 15.4 | 41 |
| 1300 | 1.06 | 9.6 | 9.3 | 20.9 | 16.8 | 45 |
| 1400 | 1.12 | 10.1 | 9.8 | 21.8 | 17.7 | 48 |
| 1500 | 1.17 | 10.7 | 10.3 | 23.1 | 18.6 | 52 |
| 1600 | 1.22 | 11.2 | 10.8 | 24.0 | 19.5 | 55 |
| 1700 | 1.27 | 11.7 | 11.4 | 25.4 | 20.4 | 59 |
| Maintenance and pregnancy (last 2 months of gestation) | | | | | | |
| 700 | 1.32 | 7.8 | 7.6 | 21.3 | 15.0 | 24 |
| 800 | 1.45 | 8.6 | 8.4 | 24.0 | 17.2 | 28 |
| 900 | 1.57 | 9.4 | 9.2 | 26.8 | 19.0 | 31 |
| 1000 | 1.69 | 10.2 | 9.9 | 29.0 | 20.4 | 35 |
| 1100 | 1.80 | 11.0 | 10.7 | 31.8 | 22.7 | 38 |
| 1200 | 1.92 | 11.7 | 11.4 | 34.0 | 24.0 | 41 |
| 1300 | 2.03 | 12.4 | 12.1 | 36.3 | 25.8 | 45 |
| 1400 | 2.13 | 13.2 | 12.8 | 38.6 | 27.2 | 48 |
| 1500 | 2.24 | 13.8 | 13.4 | 40.8 | 29.0 | 52 |
| 1600 | 2.34 | 14.5 | 14.1 | 43.1 | 30.4 | 55 |
| 1700 | 2.44 | 15.2 | 14.8 | 45.4 | 32.2 | 59 |

[a]To allow for growth, add 20 percent to the maintenance allowances, except Vitamin A, during the first lactation and 10 percent during the second lactation.

**TABLE A-7. CROSS PROTEIN AND ENERGY ALLOWANCES FOR MILK PRODUCTION (ADD TO MAINTENANCE)**

| | Milk fat (%) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3.0 | | | 3.5 | | | 3.75 | | | 4.0 | | | 4.5 | | | 5.0 | | |
| Milk/day (lb) | CP (lb) | $NE_L$ (Mcal) | TDN (lb) | CP (lb) | $NE_L$ (Mcal) | TDN (lb) | CP (lb) | $NE_L$ (Mcal) | TDN (lb) | CP (lb) | $NE_L$ (Mcal) | TDN (lb) | CP (lb) | $NE_L$ (Mcal) | TDN (lb) | CP (lb) | $NE_L$ (Mcal) | TDN (lb) |
| 1 | .077 | .29 | .28 | .082 | .31 | .30 | .084 | .32 | .32 | .087 | .34 | .33 | .092 | .36 | .34 | .098 | .38 | .36 |
| 10 | .77 | 2.9 | 2.8 | .82 | 3.1 | 3.0 | .84 | 3.25 | 3.15 | .87 | 3.4 | 3.3 | .92 | 3.6 | 3.4 | .98 | 3.8 | 3.6 |
| 20 | 1.54 | 5.8 | 5.6 | 1.64 | 6.2 | 6.1 | 1.68 | 6.50 | 6.30 | 1.74 | 6.8 | 6.5 | 1.84 | 7.2 | 6.9 | 1.96 | 7.6 | 7.3 |
| 30 | 2.31 | 8.7 | 8.5 | 2.46 | 9.3 | 9.1 | 2.54 | 9.75 | 9.45 | 2.61 | 10.2 | 9.8 | 2.76 | 10.8 | 10.3 | 2.94 | 11.4 | 10.9 |
| 40 | 3.08 | 11.6 | 11.3 | 3.28 | 12.4 | 12.2 | 3.38 | 13.00 | 12.60 | 3.48 | 13.6 | 13.0 | 3.68 | 14.4 | 13.8 | 3.92 | 15.2 | 14.6 |
| 50 | 3.85 | 14.5 | 14.1 | 4.10 | 15.5 | 15.2 | 4.22 | 16.25 | 15.75 | 4.35 | 17.0 | 16.3 | 4.60 | 18.0 | 17.2 | 4.90 | 19.0 | 18.2 |
| 60 | 4.62 | 17.4 | 16.9 | 4.92 | 18.6 | 18.2 | 5.07 | 19.50 | 18.90 | 5.22 | 20.4 | 19.6 | 5.52 | 21.6 | 20.6 | 5.88 | 22.8 | 21.9 |
| 70 | 5.39 | 20.3 | 19.7 | 5.74 | 21.7 | 21.3 | 5.92 | 22.75 | 22.05 | 6.09 | 23.8 | 22.8 | 6.44 | 25.2 | 24.1 | 6.44 | 26.6 | 25.6 |
| 80 | 6.16 | 23.2 | 22.6 | 6.56 | 24.8 | 24.3 | 6.76 | 26.00 | 25.20 | 6.96 | 27.2 | 26.1 | 7.36 | 28.8 | 27.5 | 7.84 | 30.4 | 29.2 |
| 90 | 6.93 | 26.1 | 25.4 | 7.38 | 27.9 | 27.4 | 7.60 | 29.25 | 28.35 | 7.83 | 30.6 | 29.3 | 8.28 | 32.4 | 31.0 | 8.82 | 34.2 | 32.8 |
| 100 | 7.70 | 29.0 | 28.2 | 8.20 | 31.0 | 30.4 | 8.45 | 32.50 | 31.50 | 8.70 | 34.0 | 32.6 | 9.20 | 36.0 | 34.4 | 9.80 | 38.0 | 36.5 |

**TABLE A-8. CALCIUM AND PHOSPHORUS ALLOWANCES FOR MILK PRODUCTION (ADD TO MAINTENANCE)**

| Milk/day (lb) | Milk fat % 3.0 Ca | 3.0 P | 3.5 Ca | 3.5 P | 3.75 Ca | 3.75 P | 4.0 Ca | 4.0 P | 4.5 Ca | 4.5 P | 5.0 Ca | 5.0 P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (grams) | | | | | | | | | | | |
| 1 | 1.1 | .8 | 1.2 | .8 | 1.2 | .8 | 1.2 | .8 | 1.3 | .9 | 1.3 | .9 |
| 10 | 11 | 8 | 12 | 8 | 12 | 8 | 12 | 8 | 13 | 9 | 13 | 9 |
| 20 | 23 | 15 | 24 | 16 | 24 | 16 | 24 | 16 | 25 | 17 | 26 | 17 |
| 30 | 34 | 23 | 35 | 24 | 36 | 24 | 37 | 24 | 38 | 26 | 39 | 26 |
| 40 | 45 | 31 | 47 | 33 | 48 | 33 | 49 | 33 | 51 | 34 | 53 | 34 |
| 50 | 57 | 38 | 60 | 41 | 60 | 41 | 61 | 41 | 64 | 43 | 66 | 43 |
| 60 | 68 | 46 | 71 | 49 | 72 | 49 | 73 | 49 | 76 | 52 | 79 | 52 |
| 70 | 79 | 54 | 82 | 57 | 84 | 57 | 86 | 57 | 89 | 60 | 92 | 60 |
| 80 | 91 | 62 | 94 | 65 | 96 | 65 | 98 | 65 | 102 | 69 | 105 | 69 |
| 90 | 102 | 69 | 106 | 73 | 108 | 73 | 110 | 73 | 114 | 78 | 118 | 78 |
| 100 | 113 | 77 | 118 | 82 | 120 | 82 | 122 | 82 | 127 | 86 | 132 | 86 |

**TABLE A-9. NUTRIENT VALUES OF COMMON FORAGES (BASED ON 100 PERCENT DRY MATTER)**

| Forages | Crude protein % | Crude fiber % | TDN % | Net energy Mcal/lb milk | Net energy Mcal/lb growth | Calcium % | Calcium gram/lb | Phosphorus % | Phosphorus gram/lb |
|---|---|---|---|---|---|---|---|---|---|
| Alfalfa - early vegetative | 22 | 24 | 65 | .67 | .37 | 2.12 | 9.6 | .30 | 1.4 |
| - early bloom | 17 | 31 | 58 | .59 | .27 | 1.25 | 5.6 | .23 | 1.0 |
| - mid bloom | 16 | 33 | 56 | .57 | .23 | 1.35 | 6.1 | .22 | 1.0 |
| - full bloom | 14 | 35 | 52 | .47 | .21 | 1.26 | 5.7 | .20 | .9 |
| Alfalfa (1/2) - Grass (1/2) | 13 | 33 | 56 | .53 | .23 | 1.03 | 4.7 | .30 | 1.4 |
| Barley, all analyses | 9 | 27 | 56 | .57 | .26 | .21 | 1.0 | .30 | 1.4 |
| Birdsfoot trefoil, early bloom | 15 | 30 | 60 | .61 | .32 | 1.75 | 7.9 | .22 | 1.0 |
| Bromegrass - late vegetative | 10 | 32 | 54 | .52 | .43 | .37 | 1.7 | .31 | 1.4 |
| - late bloom | 7 | 40 | 51 | .48 | .37 | .30 | 1.4 | .26 | 1.2 |
| Clover, alsike, average | 15 | 29 | 55 | .62 | .30 | 1.31 | 5.9 | .25 | 1.1 |
| Clover, ladino, early cut | 23 | 19 | 61 | .62 | .31 | 1.38 | 6.3 | .24 | 1.1 |
| Clover, red, average | 15 | 30 | 58 | .59 | .28 | 1.49 | 6.8 | .25 | 1.1 |
| Corn silage, early dent | 9 | 21 | 71 | .71 | .45 | .28 | 1.3 | .21 | 1.0 |
| late dent | 8 | 26 | 70 | .70 | .45 | .31 | 1.4 | .19 | .9 |
| with 10 lb urea/T | 12 | 26 | 70 | .70 | .45 | .31 | 1.4 | .19 | .9 |
| Corn stover (no ears) | 6 | 32 | 50 | .47 | .25 | .60 | 2.7 | .09 | .4 |
| Oats - boot (early flower stage) | 14 | 33 | 60 | .56 | .29 | .26 | 1.2 | .24 | 1.1 |
| - dough stage | 9 | 36 | 53 | .47 | .21 | .37 | 1.7 | .17 | .8 |
| Orchardgrass, average | 10 | 34 | 57 | .51 | .25 | .45 | 2.0 | .37 | 1.7 |
| Peas and oats | 15 | 29 | 51 | .48 | .26 | .56 | 2.5 | .29 | 1.3 |
| Quackgrass, average | 11 | 39 | 55 | .39 | .20 | .34 | 1.5 | .28 | 1.3 |
| Reed canary grass, average | 11 | 32 | 50 | .44 | .28 | .37 | 1.7 | .18 | .8 |
| Sorghum | 6 | 29 | 58 | .58 | .28 | .35 | 1.6 | .20 | .9 |
| Sorghum-sudangrass, immature | 17 | 31 | 70 | .72 | .45 | .43 | 1.9 | .41 | 1.8 |
| mid-bloom | 9 | 36 | 63 | .66 | .35 | .43 | 1.9 | .41 | 1.8 |
| Soybean hay | 16 | 32 | 52 | .48 | .16 | 1.29 | 5.9 | .23 | 1.0 |
| Straw, oats | 4 | 41 | 48 | .48 | .16 | .26 | 1.2 | .07 | .3 |
| wheat | 4 | 41 | 44 | .40 | .04 | .21 | 1.0 | .08 | .4 |
| barley | 4 | 42 | 47 | .44 | .10 | .24 | 1.1 | .09 | .4 |
| Timothy, immature | 12 | 33 | 54 | .50 | .28 | .60 | 2.7 | .26 | 1.2 |
| mature | 8 | 34 | 47 | .46 | .25 | .38 | 1.7 | .18 | .8 |
| Wheat, all analyses | 7 | 28 | 52 | .60 | .39 | .14 | .6 | .18 | .8 |

**TABLE A-10. NUTRIENT VALUES OF COMMON GRAINS AND BY PRODUCT FEEDS (BASED ON 100 PERCENT DRY MATTER)**

| Grain | Crude protein % | Crude fiber % | TDN % | Net energy Mcal/lb milk | Net energy Mcal/lb growth | Calcium % | Calcium gram/lb | Phorphorus % | Phorphorus gram/lb | Maximum level |
|---|---|---|---|---|---|---|---|---|---|---|
| Barley | 14 | 6 | 83 | .87 | .59 | .05 | .2 | .37 | 1.7 | 75 |
| Beans, field or navy | 25 | 5 | 83 | .86 | .59 | .17 | .8 | .63 | 2.9 | 20 |
| Beet pulp, plain | 8 | 22 | 78 | .81 | .54 | .75 | 3.4 | .11 | .5 | 30 |
| Beet pulp, molasses | 10 | 17 | 78 | .81 | .54 | .61 | 2.8 | .10 | .5 | 30 |
| Brewer's grain, dried | 26 | 16 | 66 | .70 | .38 | .29 | 1.3 | .54 | 2.5 | 33 |
| Corn and cob meal | 9 | 9 | 80 | .83 | .56 | .05 | .2 | .26 | 1.2 | 100 |
| Corn, shelled | 10 | 2 | 88 | .92 | .64 | .02 | .1 | .31 | 1.4 | 100 |
| Corn, cobs | 3 | 36 | 47 | .46 | .11 | .12 | .5 | .04 | .2 | 25 |
| Corn distillers' grain | 30 | 13 | 84 | .88 | .60 | .10 | .4 | .40 | 1.8 | 33 |
| Corn distillers' grain with solubles | 30 | 10 | 88 | .92 | .64 | .16 | .7 | .79 | 3.6 | 33 |
| Corn distillers' solubles | 29 | 4 | 88 | .92 | .64 | .38 | 1.7 | 1.47 | 6.7 | 33 |
| Corn gluten feed | 28 | 9 | 82 | .85 | .58 | .51 | 2.3 | .86 | 3.9 | * |
| Corn gluten meal | 47 | 8 | 84 | .88 | .60 | .18 | .8 | .44 | 2.0 | * |
| Cottonseed meal, solvent | 45 | 13 | 75 | .78 | .50 | .17 | .8 | 1.31 | 5.9 | * |
| Fat | – | – | 182 | 2.38 | 1.19 | – | – | – | – | 5 |
| Hominy feed | 12 | 6 | 92 | .96 | .68 | .06 | .3 | .58 | 2.6 | 100 |
| Linseed meal, solvent | 39 | 10 | 76 | .79 | .52 | .44 | 2.5 | .91 | 4.1 | * |
| Malt sprouts | 29 | 12 | 68 | .73 | .54 | .29 | 1.3 | .85 | 3.9 | 25 |
| Milk cows | 26 | 0 | 130 | 1.64 | .91 | 1.41 | 6.4 | 1.17 | 5.3 | 100 to young calves |
| Molasses, beet | 9 | 0 | 76 | .78 | .52 | .21 | 1.0 | .04 | .2 | 10 |
| Molasses, cane | 4 | 0 | 72 | .74 | .54 | 1.19 | 5.4 | .11 | .5 | 10 |
| Oats | 13 | 12 | 76 | .79 | .52 | .07 | .3 | .39 | 1.8 | 100 |
| Potatoes | 10 | 2 | 79 | .82 | .59 | .04 | .2 | .23 | 1.2 | 50 |
| Rye | 14 | 3 | 80 | .83 | .56 | .07 | .3 | .36 | 1.6 | 100 |
| Skim milk | 36 | 0 | 88 | .94 | .66 | 1.34 | 6.1 | 1.10 | 5.0 | 100 |
| Sorghum, milo | 12 | 2 | 83 | .85 | .59 | .05 | .2 | .35 | 1.6 | 100 |
| Soybean seed | 42 | 6 | 94 | .99 | .69 | .28 | 1.8 | .66 | 3.0 | 20 |
| Soybean meal, solvent | 50 | 7 | 85 | .90 | .58 | .36 | 1.6 | .75 | 3.4 | * |
| Sunflower meal | 50 | 12 | 65 | .67 | .38 | .40 | 1.8 | 1.10 | 5.0 | * |
| Wheat | 14 | 3 | 85 | .88 | .64 | .06 | .3 | .41 | 1.9 | 50 |
| Wheat bran | 18 | 11 | 70 | .77 | .44 | .12 | .5 | 1.32 | 6.0 | 100 |
| Wheat middlings | 19 | 8 | 80 | .83 | .59 | .12 | .5 | 1.00 | 4.5 | 100 |
| Wheat screenings (varies greatly) | 16 | 8 | 76 | .80 | .53 | .17 | .8 | .40 | 1.8 | 100 |
| Whey, dried | 14 | 0 | 78 | .81 | .30 | .98 | 4.4 | .81 | 3.7 | 10 |
| Yeast, brewers' | 48 | 3 | 78 | .89 | .53 | .14 | .7 | 1.53 | 6.9 | 5 |
| Yeast, torula | 52 | 2 | 80 | .83 | .56 | .61 | 2.8 | 1.81 | 8.2 | 5 |

*Add the amount needed to balance and meet protein needs.

**TABLE A-11. COMPOSITION OF CALCIUM AND PHOSPHORUS SUPPLEMENTS (100 PERCENT DRY BASIS)**

| Supplements | Calcium | | Phosphorus | |
|---|---|---|---|---|
| | % | gm/lb | % | gm/lb |
| Bone meal, steamed | 30 | 136 | 14 | 64 |
| Deflourinated phosphate rock | 32 | 145 | 14 | 64 |
| Dicalcium phosphate | 23 | 104 | 18 | 82 |
| Limestone | 36 | 163 | – | – |
| Monoammonium phosphate | – | – | 25 | 113 |
| Monocalcium phosphate | 16 | 72 | 24 | 109 |
| Monosodium phosphate | – | – | 26 | 118 |
| Oyster shell flour | 38 | 173 | – | – |
| Sodium tripolyphosphate | – | – | 26 | 118 |

**TABLE A-12. MINERAL CONTENT (OTHER THAN CALCIUM AND PHOSPHORUS) OF COMMON FEEDSTUFFS AND MINERAL SUPPLEMENTS***

| Feedstuffs | CL | Co | Cu | Fe | Mg | Mn | K | Na | S | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| | % | ppm | ppm | ppm | % | ppm | % | % | % | ppm |
| Barley | .20 | .11 | 9.1 | 90 | .15 | 19 | 0.45 | .03 | .18 | 17 |
| Corn and cob meal | – | .30 | 8.8 | 80 | .17 | 28 | 0.56 | .05 | .22 | 18 |
| Corn, shelled | .05 | .04 | 3.6 | 30 | .13 | 6 | 0.35 | .01 | .14 | 21 |
| Oats grain | .12 | .07 | 6.6 | 80 | .19 | 43 | 0.39 | .18 | .38 | 33 |
| Linseed meal | .04 | .14 | 28.2 | 360 | .66 | 41 | 1.52 | .15 | .44 | – |
| Soybean meal | .03 | .10 | 40.8 | 130 | .30 | 31 | 2.21 | .31 | .49 | 48 |
| Alfalfa, early bloom | .38 | .09 | 21.7 | 200 | .30 | 32 | 2.08 | .15 | .30 | 17 |
| Bromegrass | – | – | – | – | .09 | 33 | 2.32 | .02 | .20 | – |
| Corn silage | .04 | .06 | 13.2 | 640 | .28 | 34 | 1.05 | .01 | .08 | 21 |
| Corn stover | – | – | 5.1 | 200 | .45 | 122 | 0.92 | .07 | .17 | – |
| Timothy | – | – | – | 140 | .16 | 46 | 1.59 | .18 | .13 | – |
| Oats hay | .52 | .07 | 4.4 | 500 | .75 | 120 | 1.23 | .17 | .30 | – |
| Supplements | | | | | | | | | | |
| Magnesium oxide | – | – | – | – | 54 | – | – | – | – | – |
| Magnesium sulfate | – | – | – | – | 20 | – | – | – | 26 | – |
| Calcium sulfate | – | – | – | – | – | – | – | – | 24 | – |
| Potassium chloride | 48 | – | – | – | – | – | 52 | – | – | – |
| Potassium sulfate | – | – | – | – | – | – | 45 | – | 18 | – |

*Abbreviations: Cl = chlorine, Co = cobalt, Cu = copper, Fe = iron, Mg = magnesium, Mn = manganese, K = potassium, Na = sodium, S = sulfur, and Zn = zinc
1% = 10,000 ppm (parts per million)

## TABLE A-13. RECOMMENDED NUTRIENT CONTENT OF RATIONS FOR DAIRY CATTLE (DRY MATTER BASIS)

| | Lactating Cow Rations | | | | |
|---|---|---|---|---|---|
| | Cow Wt. (lb) | Daily Milk Yields (lb/day) | | | |
| Nutrients | ≤900 | <18 | 18 - 29 | 29 - 40 | >40 |
| | 1,100 | <24 | 24 - 37 | 37 - 51 | >51 |
| | 1,300 | <31 | 31 - 46 | 46 - 64 | >64 |
| | ≥1,550 | <40 | 40 - 57 | 57 - 78 | >78 |
| Crude Protein, % | | 13 | 14 | 15 | 16 |
| Energy | | | | | |
| $NE_l$, Mcal/lb | | 0.64 | 0.69 | 0.73 | 0.78 |
| $NE_m$, Mcal/lb | | – | – | – | – |
| $NE_g$, Mcal/lb | | – | – | – | – |
| ME, Mcal/lb | | 1.07 | 1.15 | 1.23 | 1.31 |
| DE, Mcal/lb | | 1.26 | 1.34 | 1.42 | 1.50 |
| TDN, % | | 63 | 67 | 71 | 75 |
| Crude fiber, % | | 17 | 17 | 17 | 17 |
| Acid detergent fiber | | 21 | 21 | 21 | 21 |
| Ether extract, % | | 2 | 2 | 2 | 2 |
| Minerals | | | | | |
| Calcium, % | | 0.43 | 0.48 | 0.54 | 0.60 |
| Phosphorus, % | | 0.31 | 0.34 | 0.38 | 0.40 |
| Magnesium, % | | 0.20 | 0.20 | 0.20 | 0.20 |
| Potassium, % | | 0.80 | 0.80 | 0.80 | 0.80 |
| Sodium, % | | 0.18 | 0.18 | 0.18 | 0.18 |
| Sodium chloride, % | | 0.46 | 0.46 | 0.46 | 0.46 |
| Sulfur, % | | 0.20 | 0.20 | 0.20 | 0.20 |
| Iron, ppm | | 50 | 50 | 50 | 50 |
| Cobalt, ppm | | 0.10 | 0.10 | 0.10 | 0.10 |
| Copper, ppm | | 10 | 10 | 10 | 10 |
| Manganese, ppm | | 40 | 40 | 40 | 40 |
| Zinc, ppm | | 40 | 40 | 40 | 40 |
| Iodine, ppm | | 0.50 | 0.50 | 0.50 | 0.50 |
| Molybdenum, ppm | | – | – | – | – |
| Selenium, ppm | | 0.10 | 0.10 | 0.10 | 0.10 |
| Fluorine, ppm | | – | – | – | – |
| Vitamins | | | | | |
| Vit A, IU/lb | | 1,450 | 1,450 | 1,450 | 1,450 |
| Vit D, IU/lb | | 140 | 140 | 140 | 140 |
| Vit E, ppm | | – | – | – | – |

Nonlactating Cattle Rations

| Dry Pregnant Cows | Mature Bulls | Growing Heifers and Bulls | Calf Starter Concentrate Mix | Calf Milk Replacer | Maximum Concentrations (All Classes) |
|---|---|---|---|---|---|
| 11 | 8.5 | 12.0 | 16.0 | 22.0 | – |
| 0.61 | – | – | – | – | – |
| – | 0.54 | 0.57 | 0.86 | 1.09 | – |
| – | – | 0.27 | 0.54 | 0.70 | – |
| 1.01 | 0.93 | 1.01 | 1.42 | 1.71 | – |
| 1.20 | 1.12 | 1.20 | 1.60 | 1.90 | – |
| 60 | 56 | 60 | 80 | 95 | – |
| 17 | 15 | 15 | – | – | – |
| 21 | 19 | 19 | – | – | – |
| 2 | 2 | 2 | 2 | 10 | – |
| 0.37 | 0.24 | 0.40 | 0.60 | 0.70 | – |
| 0.26 | 0.18 | 0.26 | 0.42 | 0.50 | – |
| 0.16 | 0.16 | 0.16 | 0.07 | 0.07 | – |
| 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | – |
| 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | – |
| 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 5 |
| 0.17 | 0.11 | 0.16 | 0.21 | 0.29 | 0.35 |
| 50 | 50 | 50 | 100 | 100 | 1,000 |
| 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 10 |
| 10 | 10 | 10 | 10 | 10 | 80 |
| 40 | 40 | 40 | 40 | 40 | 1,000 |
| 40 | 40 | 40 | 40 | 40 | 500 |
| 0.50 | 0.25 | 0.25 | 0.25 | 0.25 | 50 |
| – | – | – | – | – | 6 |
| 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 5 |
| – | – | – | – | – | 30 |
| 1,450 | 1,450 | 1,000 | 1,000 | 1,720 | – |
| 140 | 140 | 140 | 140 | 270 | – |
| – | – | – | – | 300 | – |

**TABLE A-14. FEED EVALUATION FACTORS FOR ESTIMATING RELATIVE VALUES OF THE ENERGY AND PROTEIN CONTENT OF COMMON FEEDSTUFFS COMPARED TO CORN AND SOYBEAN MEAL (AS IS OR WET BASIS)**

| Feed | Fiber | Feed evaluation factors | |
|---|---|---|---|
| | | Corn | Soybean meal |
| Dry forages | | | |
| Alfalfa hay, low quality | Over 36 | 0.263 | 0.153 |
| Alfalfa hay, average | 30-36 | 0.296 | 0.212 |
| Alfalfa hay, high quality | Below 30 | 0.296 | 0.259 |
| Bromegrass hay | (Average) | 0.415 | 0.060 |
| Clover, red, hay | | 0.412 | 0.106 |
| Marsh or swamp hay | | 0.383 | 0.037 |
| Mixed hay, good, less than 30 percent legume | | 0.427 | 0.039 |
| Oat hay | | 0.423 | 0.049 |
| Oat straw | | 0.326 | -0.035 |
| Orchardgrass hay | | 0.450 | 0.028 |
| Sorghum-sudan grass hay | | 0.421 | 0.035 |
| Soybean hay, average | | 0.236 | 0.196 |
| Timothy hay | | 0.469 | -0.003 |
| Wheat hay | | 0.427 | 0.011 |
| Silages | | | |
| Corn, dent, well-matured, well-eared | | 0.265 | -0.011 |
| Oats (headed out) | | 0.163 | 0.017 |
| Peas and oats | | 0.165 | 0.021 |
| Sunflower | | 0.109 | 0.007 |
| Grains | | | |
| Barley | | 0.908 | 0.093 |
| Beet pulp | | 0.931 | -0.051 |
| Brewers' grains | | 0.374 | 0.464 |
| Corn, dent | | 1.000 | 0.000 |
| Corn and cob meal | | 0.918 | -0.018 |
| Distillers' dried corn grain with solubles | | 0.710 | 0.350 |
| Linseed meal | | 0.201 | 0.699 |
| Milo grain | | 0.916 | 0.056 |
| Molasses, cane | | 1.058 | -0.169 |
| Oats | | 0.806 | 0.095 |
| Rye | | 0.765 | 0.116 |
| Screenings (low fiber) | | 0.534 | 0.134 |
| Screenings (high fiber) | | 0.432 | 0.134 |
| Soybean seed | | 0.352 | 0.746 |
| Soybean meal | | 0.000 | 1.000 |
| Sunflower meal | | -0.267 | 1.114 |
| Wheat | | 0.875 | 0.125 |
| Wheat bran | | 0.619 | 0.218 |
| Wheat standard middlings | | 0.743 | 0.222 |
| Whey | | 0.839 | 0.140 |
| Yeast, brewers | | -0.113 | 0.937 |

**TABLE A-15. CONVERSION TABLES FOR COMMON WEIGHTS AND MEASURES**

Metric conversions

1 pound = 454 grams
2.2 pounds = 1 kilogram
1 quart = 1 liter
1 gram = 15.43 grains
1 metric ton = 2.205 bands
1 inch = 2.54 centimeters
1 centimeter = 10 millimeters = .39 inches
1 meter = 39.37 inches
1 acre = .406 hectare

Bushel weights and volumes

| | |
|---|---|
| Oats = 32 lb/bu | 25 lb/cu ft |
| Barley = 48 lb/bu | 38.4 lb/cu ft |
| Shelled corn = 56 lb/bu | 44.8 lb/cu ft |
| Wheat = 60 lb/bu | 48 lb/cu ft |
| Corn and Cob Meal = 70 lb/bu | 28 lb/cu ft |
| Soybeans = 60 lb/bu | 48 lb/cu ft |
| Rye = 56 lb/bu | 44.8 lb/cu ft |

Weight of one quart of feed

Barley, whole = 1.5 lb
Barley, ground = 1.1 lb
Beet pulp, dry = .7 lb
Corn, shelled, ground = 1.5 lb
Corn and cob meal = 1.4 lb
Linseed meal = 1.3 lb
Molasses, cane = 3.0 lb
Oats, whole = 1.0 lb
Oats, ground = .7 lb
Rye, ground = 1.5 lb
Soybeans, ground = 1.4 lb
Wheat, ground = 1.7 lb

Weight conversions

8 tablespoons = 1/4 lb
3 teaspoons = 1 tablespoon
1 pint = 1 pound
2 pints = 1 quart
4 quarts = 1 gallon = 8 lb
2000 lb = 1 ton
16 ounces = 1 pound
27 cubic feet = 1 cubic yard
1 peck = 8 quarts
1 bushel = 4 pecks

Volume conversions of hay and straw

| | lb/cubic ft | | |
|---|---|---|---|
| | Loose | Chopped | Bale (reg) |
| Alfalfa | 4-4.4 | 5.5-7 | 6-10 |
| Non legume | 3.3-4.4 | 5-6.7 | 6-8 |
| Straw | 2-3 | 5.7-8 | 4-5 |

Other conversions

1% = .01
1% = 10,000 parts per million (ppm)
1 Megacalorie (M-cal) = 1000 Calories
1 Calorie (Big calorie) = 1000 calories (small calorie)
1 M-cal = 1 therm